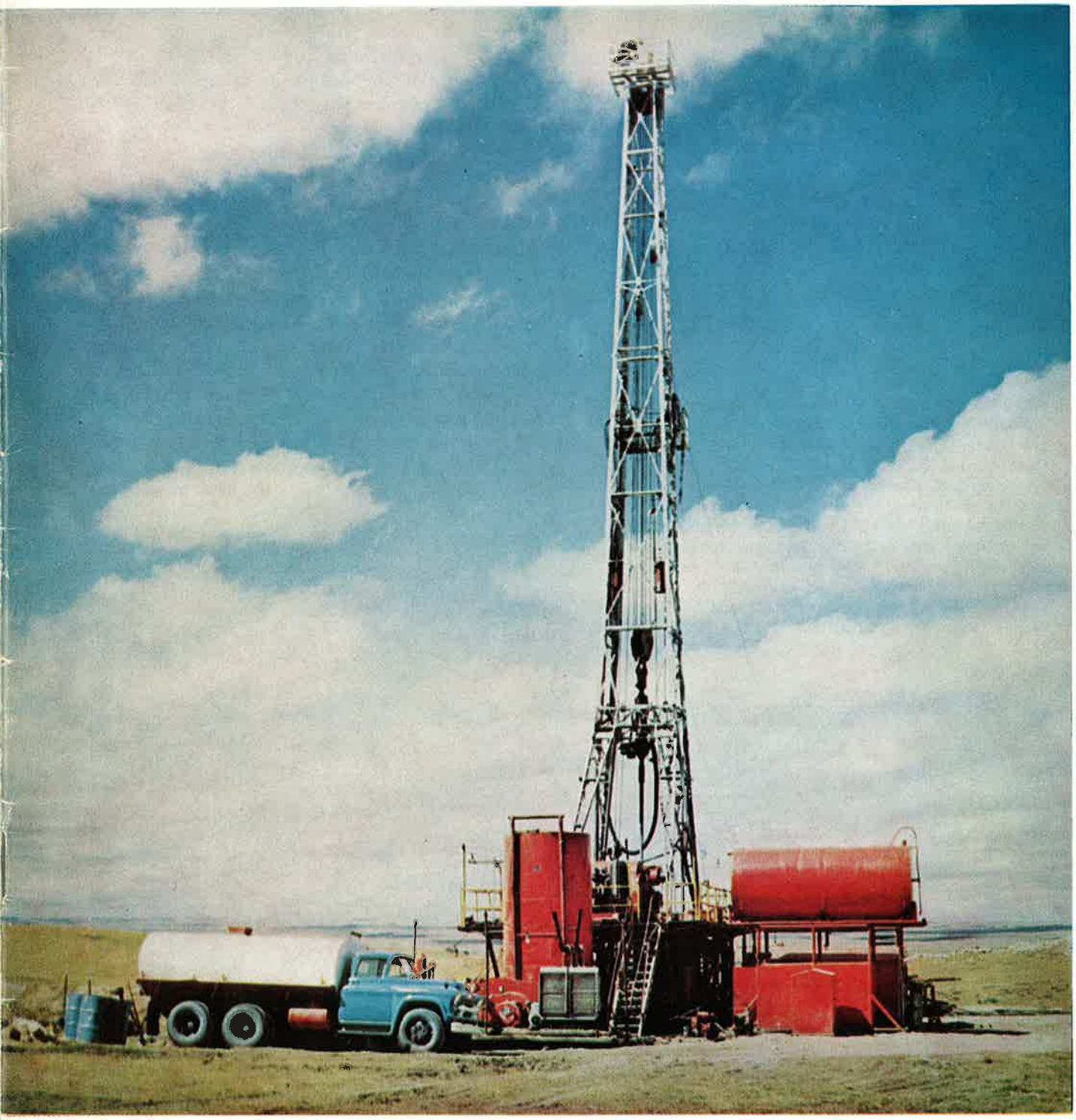
1958

Oil in Nebraska

UNIVERSITY REPORT



OIL IN NEBRASKA

Spring Issue
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Photo Story

The Odds Are 12 to 1 Your Wildcat Well Is A Dry Hole

If, after reading the article on these pages, you decide maybe you want to take a flyer in oil, the photos will give you highlights of what's ahead in a sound wildcatting venture. Much sound geological information is obtained by surface geological survey, as illustrated in (1) an instrument man recording data for a survey party, and (2) a geologist studying a sample of rock which may contain important clues. Now, if the outlook is encouraging up to this point, there is the all-important task (illustrated in photo 3) of persuading a landowner—and this isn't always easy—that your offer to drill his land is fair and based on sound geological advice.

Our desire for wealth leads us up all sorts of financial alleys.

One sort is wildcatting, which is exploring for oil anywhere beyond the limits of a producing oil field.

Now, wildcatting is a perfectly respectable business. It is estimated that Americans spend about 250 million dollars each year searching for oil. Much of this is spent by the major oil companies as a carefully calculated investment. But some of it is sucker money.

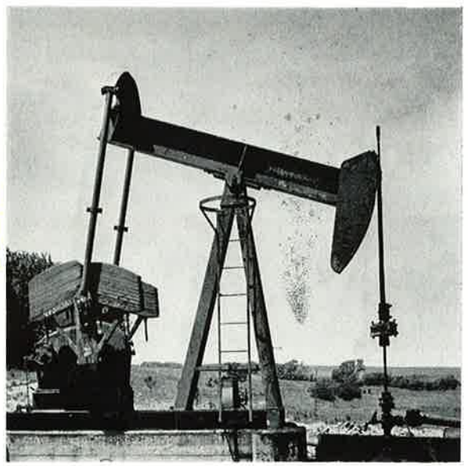
The commonest gimmick is perpetrated by the operator who is more interested in making money than finding oil. This is known as the flat-price method. It appeals to the lower-income individual who wishes to make a one-shot investment in oil. The operator has a tip on a "good location" for an oil well. Of course, he tells you, you may lose your dough. But then again, a friend of his who has been in the oil business for a very long time, is convinced that oil will be found at 4,000 feet. So he offers to sell you a share for $2,000. This may be a sixteenth of his interest which is probably seven-eighths of the well. (The landowner gets the other one-eighth.) Who knows, you tell yourself, I may strike it rich! The operator sells the rest of the shares and collects a total of $32,000. His drilling site may be selected without expert advice. But, he begins to drill. Why should he worry whether he strikes oil or granite? The well will cost him about $20,000 and he has been guaranteed a nice personal profit. This happens to be, however, the method many legitimate and trustworthy operators use in financing their test wells. You'll just have to satisfy yourself that he is a reliable operator and depends on the best technical advice available.

Wildcatting is always a risk, even when undertaken by the major oil firms, simply because there is no guarantee that oil will be found. A recent study made by a leading petroleum geologist found that the chances of discovering oil or gas in a wildcat well are about one in 12. The chances of discovering a very good oil well are about one in 42, and an excellent well about one in 158 and upwards.

Some of the pain of disappointment, should you decide to take a flyer in oil, is eased by the federal government's taxation policies. You get tax benefits whether it's a dry hole or a producer. These benefits began in 1926 to stimulate oil exploration. There are three main features of the law which are of general interest: (1) All costs of drilling a dry hole are deductible from your gross income. (2) Certain costs are deductible even if you strike oil (such as geological work, labor, equipment and fuels as costs of drilling) and these very often amount to 60 per cent of the total costs. (3) A so-called depletion allowance provides, with certain restrictions, that 27.5 per cent of your income from oil production is tax free.

Veteran oil men have this advice: If you must wildcat, find a reputable oil man recognized for his ability, honesty, and financial stability. He has competent technical information and knows how to use it. Let *him* run the show. Just remember the oil business isn't glamorous; and very few men who make a living in it are millionaires.

Now, once you have the land leased, the question is: At exactly which spot shall we drill? Here's where a seismograph survey (photo 4) will be of immense (but not foolproof) help. You are now ready to "spud in" and start drilling (Photo 5). It will take two to three crews of about five men each working around the clock anywhere from three days to three weeks to drill the hole, depending upon depth and drilling conditions. You may strike oil on your first venture and after marketing arrangements have been made you can start pumping the oil (Photo 6) and getting your share of the revenue. If the industry's odds prevail, though, you'll drill ten more wells before hitting oil.



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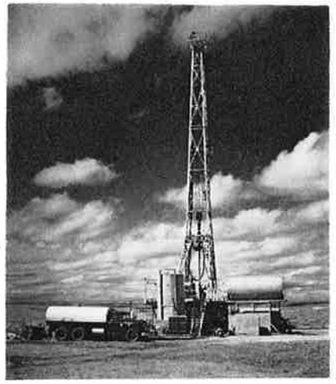


The Cover

The cover photo is of a drilling rig of the Brinkerhoff Drilling Co. of Denver, Colo. This was a successful field well drilled in the Gehrke Field south of Bushnell in Kimball County for the Pan American Petroleum Corp. The color photo was taken by Howard C. Kerr of the University's Photographic Laboratory.

Illustration Credits

CARTOGRAPHY—By Jack Brodie and Roger Metcalf, University Photographic Laboratory.

PHOTOGRAPHS—Page 2—(1), (2), Standard Oil Co. (N.J.); (3) Photographic Laboratory. Page 3—(4) Standard Oil Co. (N.J), (5) Howard Kerr, Photographic Lab., (6) Photographic Lab. Page 5—(lower), Copyright, Chicago Natural History Museum; Page 12—(left) U. of N. State Museum. (center) Nebraska State Historical Society, and (right) Thompson's Photo Center, Sidney, Nebr. Pages 28-29, (left) Howard Kerr, Photographic Lab., (right) Thompson's Photo Center, Sidney, Nebr. Pages 31, 32, 33 and 34, Howard Kerr, Photographic Lab. Back cover—Prof. A. L. Lugn, Sr.

In This Issue

Editor's Note: This issue of University Report is devoted entirely to an appraisal of the oil and gas resources of Nebraska in terms of the geological background, the long search for petroleum in the state, current production and future prospects, and the University's role in the development of this mineral wealth. The articles are generalized to give the reader a non-technical discussion of the topic.

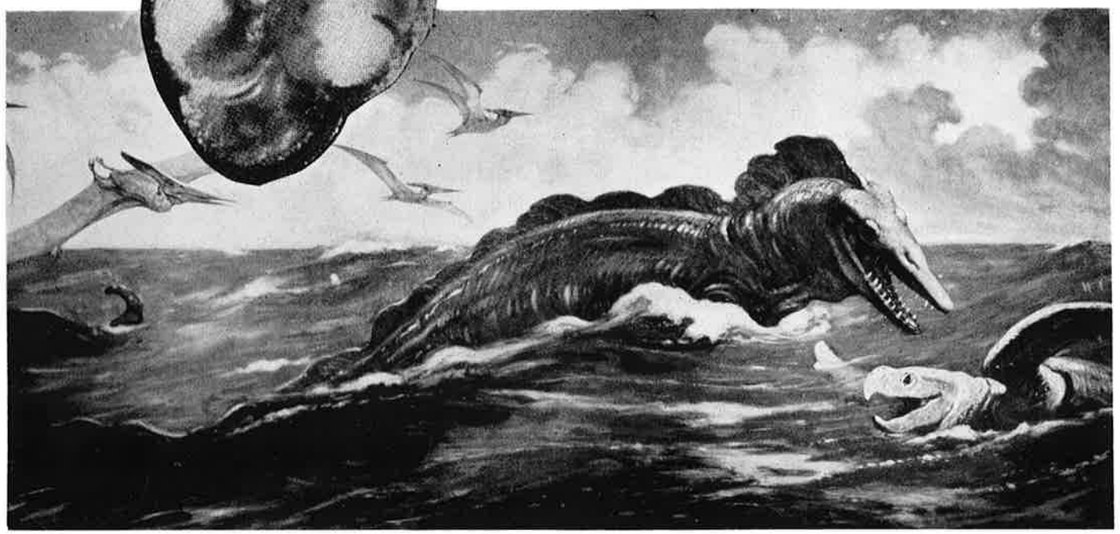
SOURCES—Sources of information include the following publications: Leonard M. Fanning, *Our Oil Resources* (1945); Kenneth K. Landes, *Petroleum Geology* (1951); Max W. Ball, *This Fascinating Oil Business* (1939); Walter A. Ver Wiebe, *Oil Fields in the United States* (1930); *Scientific American* (Dec. 1949, Nov. 1951, Oct. 1956, April 1958); *Search For Oil In Nebraska* (1942); American Institute of Mining, Metallurgical and Petroleum Engineers *Statistics* (1939 to 1957); *Natural History* (May 1, 1955); American Association of Petroleum Geologists *Bulletin* (July, 1956); *Science News Letter* (Aug. 11, 1956); *Fortune* (Aug. 1949, April 1953); State of Nebraska Board of Educational Lands and Funds *Fortieth Biennial Report* (1956); *Wall Street Journal* (Jan. 22, 1958); *New York Times* (Jan. 12, 1958); G. E. Condra, E. F. Schramm, A. L. Lugn, *Deep Wells of Nebraska* (1931); G. E. Condra, E. C. Reed, O. J. Scherer, revised by G. E. Condra and E. C. Reed *Correlation of the Laramie Range, Hartville Uplift, Black Hills and Western Nebraska* (1940, 1950); American Geological Institute *Geotimes* (Mar. 1958); *Oil and Gas Journal* (Dec. 16, 1957); E. C. Reed "Central Nebraska Has Possibilities," *World Oil* (Nov. 1954); E. C. Reed, *Favorable Reservoir Rocks in the Central Nebraska Basin,* (unpublished manuscript); R. F. Svoboda, *Exploration and Oil Discovery in Southwestern Nebraska* (unpublished manuscript). Additional information was provided in interviews with, or material especially prepared by, the following individuals: E. C. Reed, James Johnston, W. W. Garber, C. B. Schultz, E. Z. Palmer and William N. Gilliland of the University of Nebraska; Kenneth D. Monroe, Nebraska Oil and Gas Assaciation; James J. Diesing, The Kansas-Nebraska Natural Gas Co.

University Report is prepared by the Department of Public Relations under the auspices of the University of Nebraska Board of Regents: C. Y. Thompson, West Point; B. N. Greenberg, M.D. York; J. Leroy Welsh, Omaha; Clarence E. Swanson, Lincoln; Frank Foote, Axtell; J. G. Elliott, Scottsbluff.

Life
Heat and Pressure = OIL

NEBRASKA need no longer be embarrassed as a mineral-less area dependent solely on soil and water as its wealth-producing natural resources. The state is now an important oil-producing region of the United States.

This is a heartening development. For many years Nebraskans hopefully watched oil drillers bore



In the warm seas (above) which covered most of Nebraska about 90,000,000 years ago, plant and animal life abounded. Animal life ranged from the large reptiles and birds to primitive single-cell life (outlined above the drawing) called foraminifera, skeletons of which are shown here magnified 180 times. These forms of life, plus others, were source materials for the Cretaceous Age oil and gas developed under great heat and pressure in Nebraska's panhandle.

440,000,000 Years Ago

310,000,000 Years Ago

255,000,000 Years Ago

205,000,000 Years Ago

Nebraska's Ancient Seas

The maps of North America shown on these pages illustrate the succession of ancient seas (shown in blue) which deposited layers of source materials for oil. Some of these seas (classified as systems or ages) are from top to bottom: Cambrian (440,000,000 years ago); Devonian (310,000,000 years ago) which is a producing formation in the Forest City Basin; Pennsylvanian (255,000,000 years ago) which is a producing formation in Southwest Nebraska and in the Central Nebraska Basin; Triassic (205,000,000 years ago); and Cretaceous (95,000,000 years ago) which is a producing formation in the Denver-Julesburg Basin. The sedimentary basins created by these and other seas are shown in the final map, lower right, as grey areas. In these basins are found the principal oil-producing area of North America, shown in black. (For another look at these sedimentary basins

into their earth with disappointing results. Then, in 1939, in southeast Nebraska, and more recently and more importantly in the Panhandle region, significant commercial quantities of oil were found.

Production of both oil and gas have steadily increased to a point where it is now an important source of income. The extent of Nebraska's total oil and gas resource is still a moot question. It is safe to say, however, that the petroleum industry will be a productive part of the state's economy for some time to come.

The discovery of oil in Nebraska occurred at a time in history when petroleum is a major source of energy for mankind. We depend upon machines to do 96 per cent of the work in this country, and petroleum (oil and gas) provides over 55 per cent of the energy which runs them. This means that we are now consuming an enormous amount of these fuels. We will continue to do so until, perhaps, we devise ways of providing cheap and abundant atomic energy.

As long as petroleum remains king, however, the industry must continually seek new reserves of oil as old fields are exhausted. This has important implications for Nebraska. It may mean that in due time all of the potential areas of oil production – in commercial quantities—will be thoroughly explored.

The rather rapid manner by which we find oil, and then pump it out of the earth, and transport it to the consumer, contrasts sharply with the interminably slow process of forming it. The oil-producing formation in southeast Nebraska, for example, was laid down about 350,000,000 years ago. The source beds for the oil producing formations in western Nebraska were developed about 90,000,000 years ago.

THIS raises a basic question. How was Nebraska oil formed and how did it get where it is? Geologists—the men who are the experts in the history and occurrence of oil—are still working on the answer, not only about Nebraska oil but oil anywhere in the earth. Research continues unabated—at the University of Nebraska, at other educational institutions, by agencies of the government, and by the oil industry. But the kind of precise answers which will satisfy scientists and explain all known occurrences have not yet been arrived at.

Research, however, has yielded a substantial amount of evidence which provides geologists with important clues about petroleum. Many years ago, for instance, some geologists believed that oil, like all other minerals such as iron, silver and lead, was somehow the product of rock. These minerals are called inorganic substances. Geologists now know that petroleum is an organic substance; that is, it once was part of a living thing—either plant or animal.

Now, before we explore this idea further, let's look at another one. The earth is not a static or passive planet whirling through space. It has constantly changed since its beginning several billion years ago. The period we are most interested in here began about 500,000,000 years ago and which has been divided by the geologists into three eras with the imposing names of Paleozoic (old life), Mesozoic (middle life) and Cenozoic (recent life). These eras are subdivided into shorter spans of time generally called systems, several of which will be of interest to us later on.

Throughout these immense periods of time the earth's surface has been drastically shaped and reshaped. Heat, cold, wind, water and vegetation reduced rock to sand and clay and, as these sediment piled up, weight compressed them into different kinds of rock again, at other places and at other times. Had these destructive forces continued undisturbed, the earth today would be largely flat plains and shallow seas. But, while the tearing down of rock proceeded, the thick crust of the cooling earth was being subjected to great pressures. These pressures caused the surface rock to rise in some areas, and to fall in other areas. For example, the Rocky Mountains are a comparatively new feature on the face of the earth—in terms of geologic time.

Now, these tearing down and building up forces are not sudden cataclysmic eruptions. They are imperceptibly slow, extending over millions of years. They are not unique to the past. They are happening now. Our periodic earthquakes are symptoms of the rising and falling of the earth's surface; soil erosion is a symptom of the eternal tearing-down process. A spectacular example of these antagonistic forces is found in the Rocky Mountains. At the end of the long, most recent uplifting period this range was *twice* as high as it is today.

AN important aspect of the continuing change of the earth's surface has been its seas—forming, receding and forming again. The seas are of prime importance to the geologist. He now believes that it was in these ancient warm waters that the first primitive forms of life appeared. From them has developed the vast animal and plant kingdoms of today.

In general, two things happened in those seas which met the prime conditions required to form oil. The first was living things—the organic substances mentioned earlier. Life began as very small single-celled forms of life. From these evolved fish and reptiles, and seaweeds and ferns. Successive generations of billions of these small primitive living things—both plants and animals—came into being, lived, died and drifted to the bottom of the sea.

At the same time, the degrading forces of nature were destroying rock and carrying it into the seas where strong undercurrents distributed it widely.

The sediment, and the decaying forms of life, composed a vast bed of ooze or mud. As time slowly passed the sediments continued to pile up and the seas receded. Meanwhile, beneath the surface of the earth, the decaying process converted these organisms into petroleum. Geologists are still not sure how this process took place. But they are certain that it took place in what were once ancient sea floors and that oil has its origin in these ancient forms of life.

As the sediments piled up another important oil-making process was taking place. The tremendous pressure squeezed petroleum and natural gas from the ooze, and

95,000,000 Years Ago

eventually compacted some of the mud into hard, impervious rock.

Since the oil or gas could not penetrate these hard rocks even under great pressure, nature providently provided them with a place to go. They moved into the more porous rocks, generally sandstone and sometimes limestone. Up to 30 per cent of these rocks may be pore spaces.

It is evident to geologists that these pore spaces—or storage rooms—were at times as crowded as a store counter at a January sale. Part of the space was occupied by water. How did it get there? Some of the water, it is believed, may have been trapped there from an ancient sea. Other water may have seeped downward from the surface through cracks in the rock. But whatever the source, the water—itself slowly on the move—carried the oil and gas with it. Geologists are not agreed on the movement of petroleum. Some say the distances traveled were probably very short. Others believe that the petroelum may have traveled long distances through sub-surface drainage areas.

Whether the movement was long or short, it was fortunate for man that it occurred for if all the oil remained in the rocks which produced it, there would today be no deposits of commercial value. To understand the formation of petroleum pools we must answer two more questions: What causes oil to move? How was moving oil stopped so that it could be dammed up in what geologists call traps?

Now let's go back for a moment to the pressures exerted on the surface of the earth which cause it to continually rise in some places, fall in others. The rising and fall process, so interminably slow that it is accomplished over vast expanses of time, are responsible for creating two subsurface reservoirs which geologists call structural traps. These may have resulted from the gradual cooling of the earth's molten interior, or the uneven distribution of sediments on the surface, or both. At any rate, in one instance the layers of rock may be gradually folded into the form of an arch, which geologists call an anticline. As oil and gas and water move into this structure the oil and gas, because they are lighter, are pushed upward by the water to the top of the arch where they are trapped and a pool forms.

The same conditions which created the anticline may also create another structural trap called a "fault." This is an outright fracture of the earth's outer surface esulting in a series of rock formations slipping past one another. When the facture was completed a layer of impervious rock may be lodged against a layer of porous rock. As the oil moves upward through the porous rock to displace water in the pore spaces, it finally lodges against the dead end of impervious rock and the oil collects as a deposit of commercial value.

We must now take another look at the sediments which were deposited in the ancient seas. Some porous layers of a delta, or a reef, built up by deposits of sediments and of decaying marine life, sometimes became trapped or pinched off by impervious rock forming above and below it, holding the petroleum in the enclosed porous rock, and preventing further upward migration. The largest oil field ever found, East Texas, is of this type. Geologists call this a stratigraphic trap. There are several variations of this type.

To sum up briefly, then, oil is derived from the decomposition of organic materials found in the mud of sediments dumped into the ancient seas. Pressures from various causes create subsurface hills and valleys and at the same time, provide petroleum with "drainage" areas (large or small) and even more importantly, traps or collecting points.

There is some evidence to support the theory that petroleum formation follows a series of more or less distinct steps: First, a waxy substance, then asphalt, then heavy oil, then lighter oil, then still lighter oil, then lightest oils, then wet gas, and finally dry gas. (Geologists aren't at all sure about gas. It may follow these steps, or it may not.) At any rate, there seems to be some agreement on this point: Not all these steps need take place in the original ooze or source beds.

This bears on another point in the oil-making process. A current theory holds that since oil comes from once-living things (plant or animal), the kind of oil formed depends on the nature of the living things. Further, some geologists believe that water is responsible for determining in part the quality of the oil, the influence varying with the kind and quantity of minerals in the water. The point is, no two fields yield exactly the same kind of crude oil. They vary to some degree.

Oil is a mixture, and each oil is a different mixture. This mixture is made up of chemical compounds composed mainly of atoms of hydrogen and carbon, but sometimes including atoms of oxygen, nitrogen and sulfur. Some oils have many compounds. Others have very few. These compounds groups themselves into several series, the two principal ones called Paraffin and Asphalt. From each of these, in varying degrees, refiners extract such products as heating gas, kerosene, gasoline, diesel fuel, fuel oil, lubricating oils and certain solids. The main difference between them is the chemical combination of the molecules.

Now these compounds in crude oil range from very light to very heavy. Yet if we were to pump them into a tank they do not separate out—like cream-on-top milk. Crude oil behaves like homogenized milk, keeping all of its parts in solution.

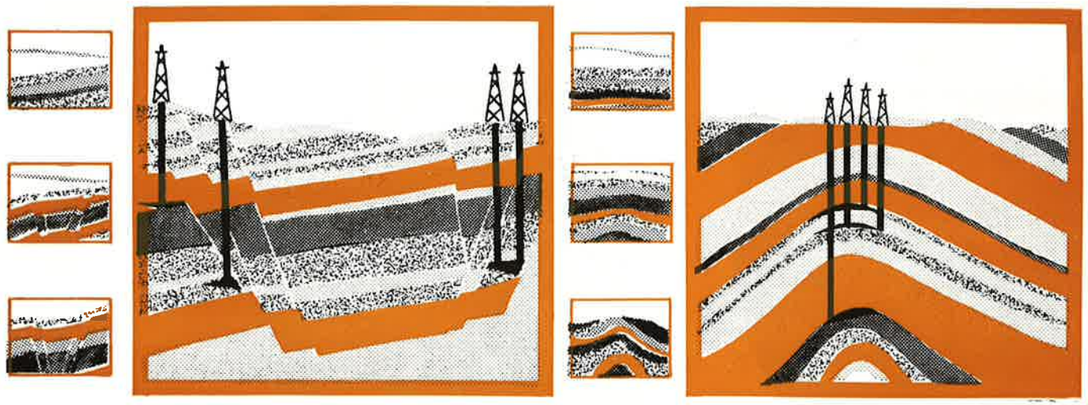
Geologists can tell very quickly the general nature of oil coming from a well by determining its specific gravity. Specific gravity, as you will recall, is the weight of a given volume of a substance, in this case oil, compared to the weight of the same volume of water. Now, because oil is lighter than water, specific gravity is measured in decimal fractions of less than one. Since this is cumbersome, oilmen have developed a convenient index called API gravity. The higher the number the lighter the oil, just reversing specific gravity. API gravity ranges from 5 (very heavy oil) to 65 (very light oil), which illustrates also the wide difference in the character of crude oils.

In Nebraska, the crude oils from southeastern fields have API gravities ranging from 27 to 30 and are generally considered to be a part of the Asphalt Series. Crude oils from the Panhandle area have API gravities ranging from 35 to 40 and are considered to be in the Paraffin Series. However, many crudes are truly mixed base oils.

The fact that oil exists in Nebraska means, of course, that the basic conditions for the formation of oil have been met in this state in ages past. How these conditions have evolved into formation of oil pools in commercial quantities involves a long hard look at Nebraska's "geologic basement," which has been formed by the impervious rock upon which the oil reservoir rests. It is at this point that the geologist, and the oil driller match wits with nature. The question is: Where can the oil be found?

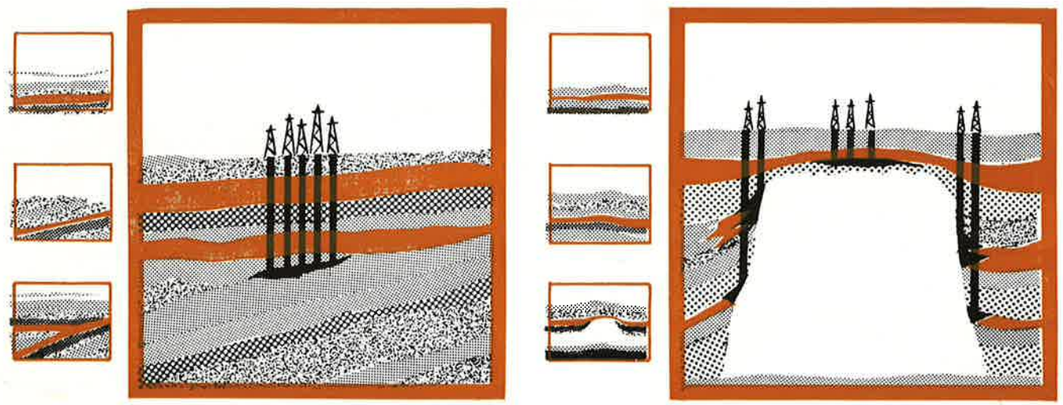
When the earth's crust is broken or fractured, a layer of oil-bearing rock slips downward, bringing the broken edge of the reservoir rock against a layer of rock that is impervious to oil. At this point the oil is "dammed up" in what is called "a fault trap." Nebraska has such traps, but none has produced.

The commonest type of nature's subsurface oil reservoirs is called an anticline trap. This is an arch or fold of porous rock in which the oil is trapped above, and sometimes below, layers of impervious rock. Generally, oil rests on top of water in this type trap. This type yields oil in Richardson.



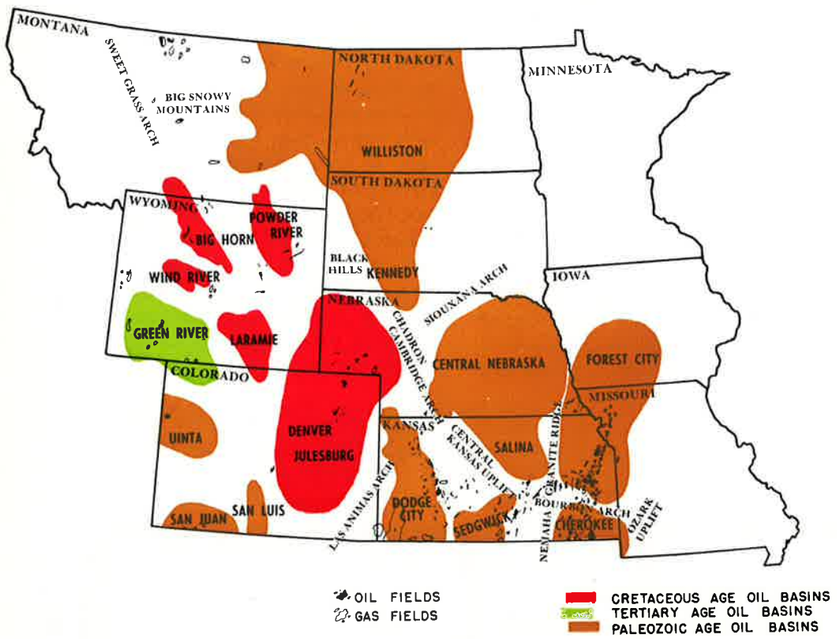
A common oil reservoir in Nebraska's panhandle is the stratigraphic trap. In this illustration part of an ancient sea bottom was lifted up, tilted and eroded. When again inundated, new sediments were deposited at an angle. Oil collected at the point where the oil-reservoir rock "pinches out."

Still another type of oil reservoir is the reef trap. This occurs in fields which lie in ancient, buried reefs which were originally built up from the sea floor by tiny marine organisms. Later, these reefs were buried under layers of rock to become mound-shaped oil reservoirs.

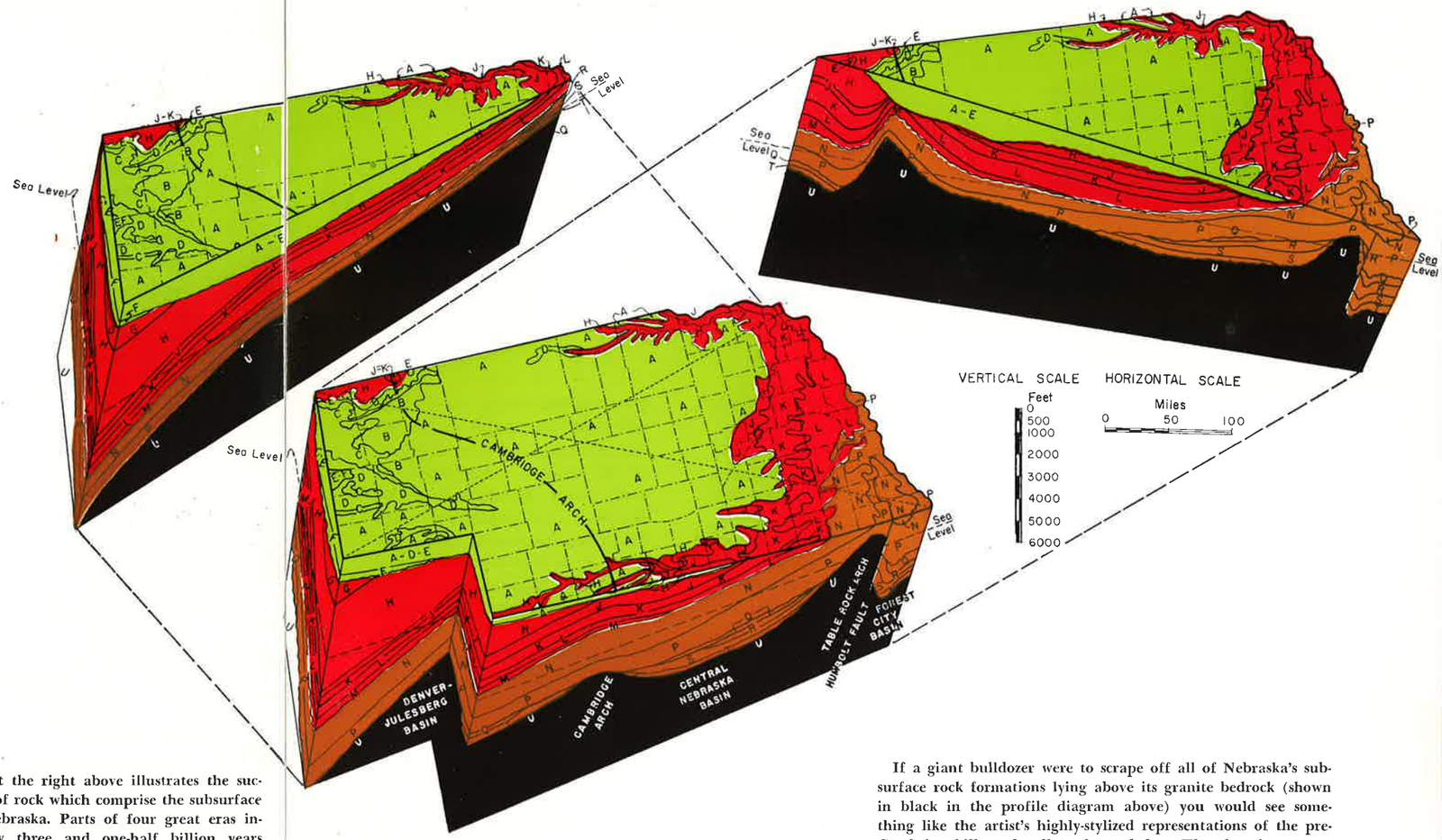


A Look at Nebraska's Bedrock Geology and Sedimentary Basins

The illustrations on these pages show graphically two major factors which have a vital influence on petroleum formation and accumulation. The first of these is the more or less systematic layers of rock which were laid down as an ooze composed of (a) sediments washed into the ancient seas, and (b) the animal and plant life abounding in those seas which died and dropped to the bottom. This source material, under tremendous heat and pressure, was converted into petroleum. The second fact is that the slow but inevitable crustal movements of the earth is a constant raising and lowering process, shaping and reshaping the bedrock into "hills" and "valleys" in which are found traps or reservoirs capable of accumulating commercial quantities of oil.

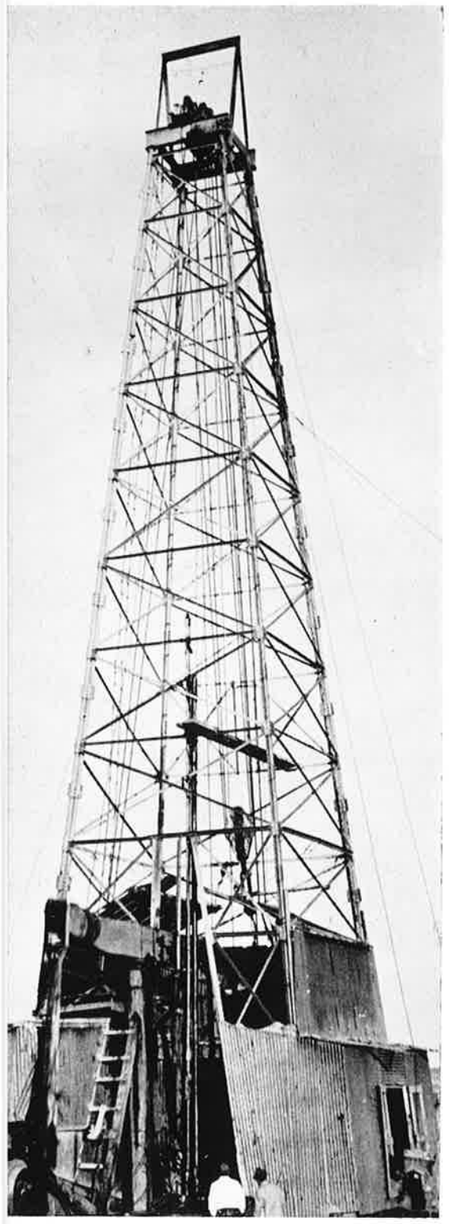


The great oil-producing basins, and uplifts or arches, of the Rocky Mountain and Mid-Continent Oil Provinces are shown in the generalized map above. The relationship of Nebraska's four sedimentary basins, and major uplifts, to those in adjacent states will help orient Nebraskans to the current stage of oil development in these provinces. The principal producing formation in each of these basins is designated by color: Tertiary —green; Mesozoic (mainly Cretaceous) red; and Paleozoic (mainly Pennsylvanian and Devonian in Nebraska) in brown.



The map at the right above illustrates the successive layers of rock which comprise the subsurface geology of Nebraska. Parts of four great eras involving nearly three and one-half billion years of geologic time are shown. The Cenozoic Era (green color) is represented by its Tertiary System which in Nebraska includes the following groups or formations: A—Ogallala, B—Hemingford, C—Arikaree, D—Brule, E—Chadron, and F—Lance. These rocks are 1,000,000 to 60,000,000 years old and constitute about one-half of one per cent of known geologic time. The Mesozoic Era (shown in red) is represented by two of its three systems—The Cretaceous (which produces oil in the Denver-Julesberg Basin) and the Jurassic. The Cretaceous groups or formations represented in Nebraska are: G—Fox Hills, H—Pierre, J—Niobrara, K—Benton, and L—Dakota. The Jurassic System is represented by the letter M. The Mesozoic formations in Nebraska are 60,000,000 to 175,000,000 years old and represent three per cent of known geologic time. The Paleozoic Era, shown in brown, is represented in Nebraska by six systems: N—Permian, P—Pennsylvanian, (which produces oil in Harlan County and Southwest Nebraska), Q—Mississippian, R—Devonian-Silurian (which is the principal oil producing formation in the Forest City Basin in Richardson County), S—Upper Ordivician, and T—the Cambro- Ordivician. The Paleozoic Era constitutes seven per cent of geologic time and is 215,000,000 to 500,000,000 years old. The granite bedrock of Nebraska is the Pre-Cambrian System shown in black, which ranges in age from 500,000,000 to 3,300,000,000 years ago and constitutes 87 per cent of known geologic time.

If a giant bulldozer were to scrape off all of Nebraska's subsurface rock formations lying above its granite bedrock (shown in black in the profile diagram above) you would see something like the artist's highly-stylized representations of the pre-Cambrian hills and valleys shown below. The elevations range from 1,000 feet above sea level (white) to 4,500 feet below sea level (black).



Nebraska's search for oil was finally fulfilled when the Bucholz Well in Richardson County (above) officially became on July 27, 1940, the first commercial producer to qualify for the $15,000 bonus offered by the State of Nebraska.

The Search For Oil In Nebraska

For Many Years Our Hopes For Mineral Wealth Rose and Fell as Drillers Fruitlessly Hunted For Petroleum But at Long Last Our Patience Has Been Amply Rewarded

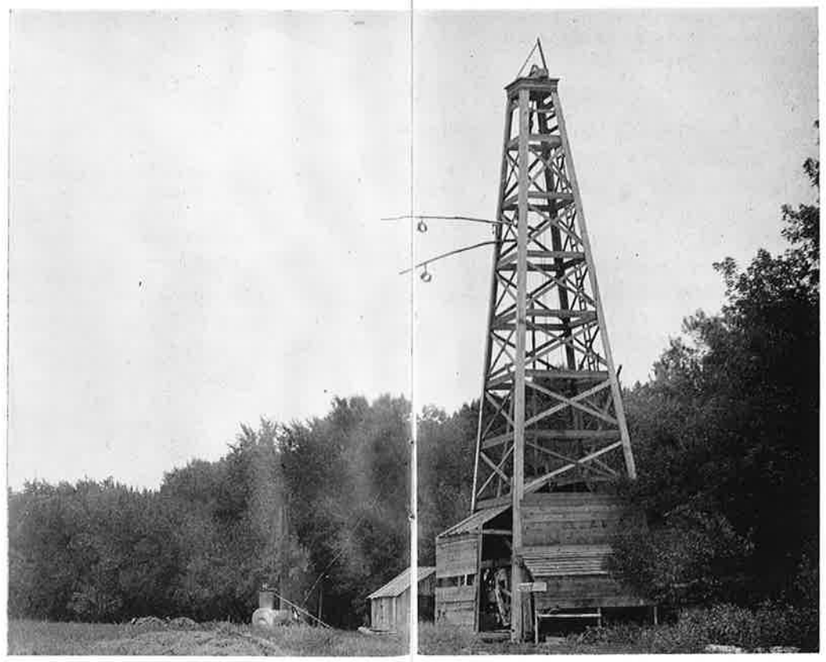
It seems reasonable, looking back from this vantage point in history, that Nebraskans should have been sporadically obsessed with searches for mineral bonanzas. After all, the principal source of wealth was the soil, and tilling it wasn't always a rewarding task.

The early settlers, and even those who came later, frequently and eagerly seized upon every rumor that great wealth lay hidden beneath the soil. There were efforts to find gold, coal and other minerals, but the persistent excitement was oil and gas.

The oil bonanza hunt continued, off and on, for 75 years without success. Then, in 1939, oil *was* discovered and since then exploration has grown, spurred on by development of a substantial number of commercial fields.

Nebraska's sporadic oil (and gas) fever, prior to actual discovery, had two unfortunate consequences. The first was that many of the so-called oil drilling tests failed because they were promoted by "doodlebug artists," outright swindlers, and eager but misinformed local boosters. Frequently these operators, prior to passing the hat, promoted pseudo-scientific rumors of oil discoveries. Others, armed with nothing more than forked willow branches, or "divining rods," or other fake apparatus, could point to the exact spot where oil would be found. Many believed them, and over a period of 75 fruitless years, spent at least several hundred thousand dollars on abortive oil tests. Many of these poorer, but wiser, individuals became willing witnesses to a belief that Nebraska was doomed to be a mineralless state.

A second consequence was that the oil swindles obscured bona fide efforts by competent geologists and drillers to locate oil in Nebraska. Many genuine tests were made at a considerable expenditure of money, all of which were adding to the sum of geologic information needed to determine, with accuracy, if the conditions necessary for oil development and collection existed in Nebraska. This work was carried on by several reputable oil companies, by competent independent drillers, and by agencies of the government including the University of Nebraska's Division of Conservation and Survey.

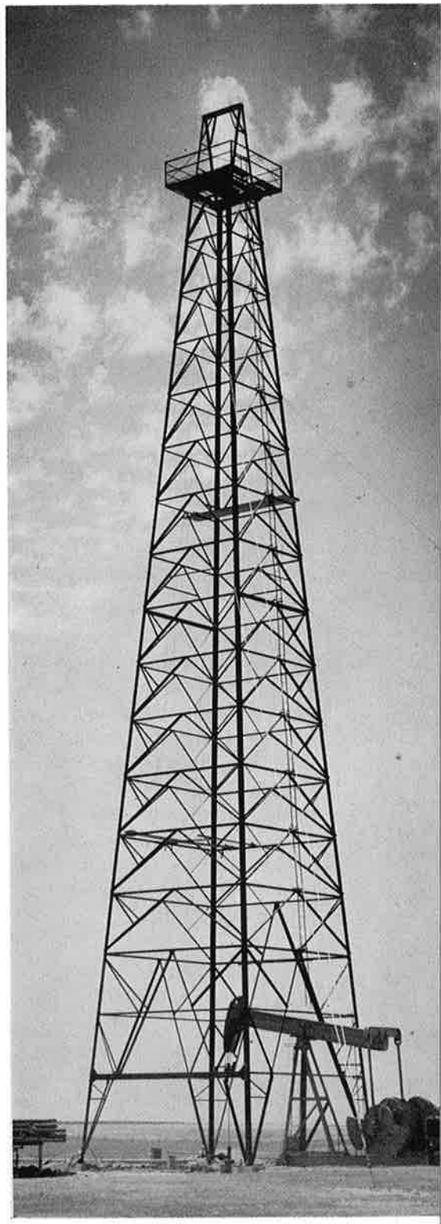


This is the Morris Oil derrick, operating near Shelton in Buffalo County in 1910. It is typical of the early wood-derrick, cable-tool type of drilling rig which dotted the Nebraska landscape for many years.

You might say that Nebraskans were first infected with the oil fever in 1865. In August of that year a newspaper reported that "coal oil" was discovered at the bottom of the Platte River near Fort Kearney. This was followed by similar reports over a period of years. Most of them described oily spots appearing in streams. Unhappily, most of this oil originated with decaying vegetable matter near the surface, or consisted of a scum of iron oxide on the water's surface, but there was no one to point this out at the time.

The rumor mill speeded up. In 1883 there was a report in the newspapers that a "vein of petroleum" had been discovered near Salem. A geologist described the oil as "superior to that found in Pennsylvania." But somehow no one ever saw the oil, nor was anything done about it.

Five years later the fever rose again. At Dannebrog it was noticed that there were places on Oak Creek where the ice would not form. A schoolboy touched a match to bubbles rising to the surface of the creek, and they sputtered into a flame. A short time later a Dannebrog man



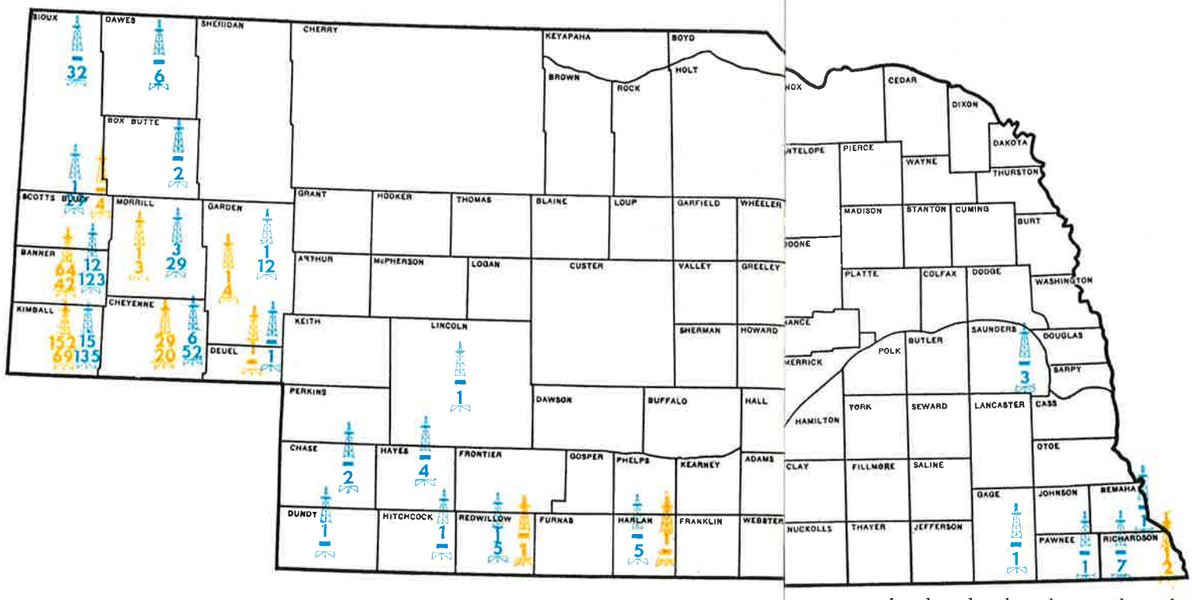
Nebraska's oil development moved rapidly ahead in the Panhandle counties following the discovery of oil in the Gurley Field near Sidney. This is the discovery well, the Mary Egging No. 1, drilled by the Ohio Oil Co.

placed a wash tub, equipped with a petcock, over the bubbles. After sufficient gas accumulated, he lit it and a gas flame spurted like a jet stream from the petcock. People were attracted to this sight from miles around.

Near Hastings a similar event occurred. The excited residents subscribed $10,000 to pipe gas to the city. But, of course, the project was later abandoned; not enough gas. The newspapers, however, were adamant: Nebraska was underlain with a pool of natural gas! The bug bit Omaha. Money was raised to drill a well. No gas was found but there was a showing of coal. Citizens were hopeful that Omaha would become the Pittsburgh of the midwest. The coal vein, however, turned out to be too small for mining.

And so it went. Newspapers reported oil and gas discoveries at Crawford, Dannebrog (again), Craig and near Elmwood. Then in 1902 Omaha had another fling. This involved determining the source of "oil streaks" on the surface of Pappio Creek. Over $1,000,000 was subscribed, according to the Omaha *World-Herald,* to develop the bonanza. But it fizzled out.

Oil scouts and drillers came and went. In some instances local citizens, particularly in western Nebraska where there was considerable activity, became suspicious of all operators because of previous failures. This was natural, but in one instance it proved foolish. In 1919, near Riverton, a reputable Oklahoma driller offered to drill a well if leases could be obtained from local landowners. The company did not demand local capital. The citizens of the area decided that if the company was willing to gamble thousands of dollars of its own money, prospects must



Nebraska's 1957 Drilling Record

In 1957 there were 887 oil and gas wells completed in twenty-two Nebraska counties. Of these, 291 were successful. In the map above, wildcat wells are shown in blue, the top number being producers and the bottom number the dry holes drilled. The field wells are shown in yellow, the top number representing producers and the bottom number dry holes.

be good indeed. So, they drilled themselves, without success.

The excitement generated by these oil drilling ventures can be measured by the comments of the newspapers. "Shortly we will have millionaires galore, speeding in Super-Sixes o'er the tranquility of silent hills and fertile valleys" (Red Cloud); "With such a large area of land leased by the company, it is figured that thousands of wells can be put down and that the output will be beyond estimation" (Omaha); "Nebraska is no doubt due for one of the great booms which are coming to only a few states in the Union" (Stockville); and this one (almost, and unwittingly, prophetic), appearing in 1917 in the Harrisburg paper, "It's our guess that oil will be struck out there and it may happen any day." The editor was just about 34 years ahead of his time.

There is other evidence. At Riverton, in 1920, a locally backed well was "spudded in" with an elaborate ceremony. The driller, departing from the usual custom at these events, said simply: "The well should do the boring," not the speakers. At Beatrice a driller's tool was lodged at the bottom of the hole. Local backers became impatient with efforts to recover the tool and finally the operator quit, saying he was "hampered on all sides." At Beaver City, in 1928, so many people crowded around a drilling venture asking questions that harried crewmen finally posted a large sign, "Ask no questions and we will tell you no lies."

The newspaper accounts make

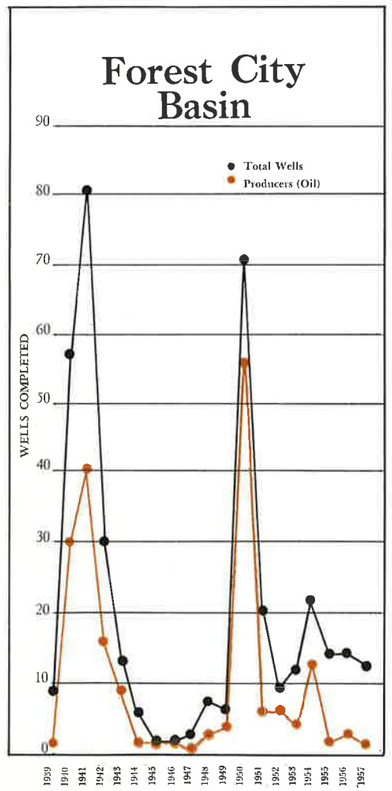
it abundantly clear that the rumors about oil and gas discoveries were far more numerous than the reports of actual drillings, and the accounts of the drillings make it clear that most of them were abandoned at shallow depths of several hundred feet, considerably shy of the depth required to penetrate oil bearing formations in Nebraska.

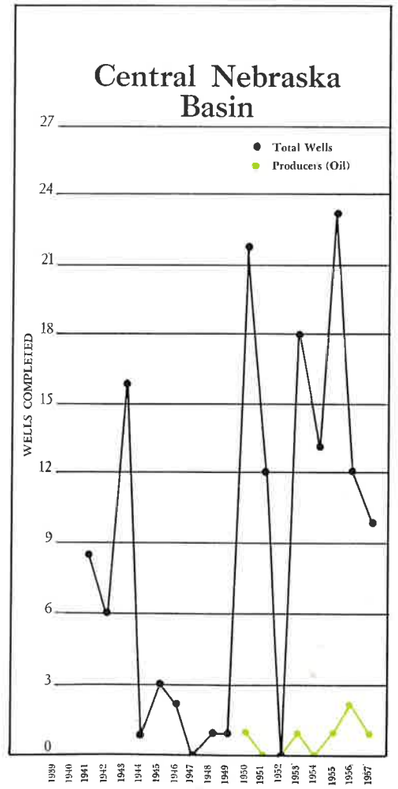
The records of the Division of Conservation and Survey show only one deep well test prior to 1903, this one an effort to locate gas near Dannebrog in 1889. The Division of Conservation and Survey, which includes the State Geological Survey, was not established until 1921 when it became the duty of the Division to preserve the records of all deep well drillings. Since that date, the records of deep well tests are very nearly complete.

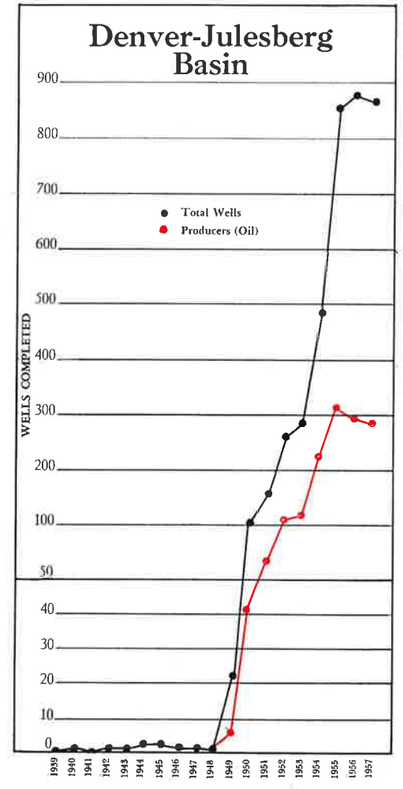
The Division's records show only 35 bona fide deep well tests were made in the 1903-1929 period, and 39 tests in the 1930-39 period. Many of these wells, although all were unsuccessful or dry holes, were undertaken upon the best geological advice possible and drilled by reputable companies including the Ohio

Wells Completed Versus Producers

The three charts shown below measure the drilling activity in Nebraska principal oil basins. The black lines represent the total number of wells completed. The color lines show the number of producers. The ratio of total wells to producers is much more favorable here because field wells as well as wildcat wells are included.







Oil Company, the Amerada Petroleum Company and the Union Oil Company.

A POPULAR drilling area for wildcatters—wildcatters are drillers who search for new producing areas—has been Richardson County. In the spring of 1939 there was considerable geologic exploration of the County. In the summer, a site was selected on the R. H. Boice quarter-section, three miles west of Falls City by its sponsors, the Guinn Brothers of Texas. At the spudding in, in September, there was no fanfare. Mr. William Guinn said simply, "We'll get out the brass bands if we bring in a well."

On November 2, 1939 oil was found in the Boice well, but the drilling was hampered with substantial amounts of water. Efforts were made to bring in a steadier flow of oil. A test run was commenced to try to qualify the well for the $15,000 bonus offered by the State of Nebraska for the first commercial oil well. The test ended unsuccessfully 18 days later. Meanwhile, the Guinn brothers drilled another well on the nearby Mabel Meyer farm, but it was unsatisfactory. The Guinns started a third well in April, 1940 on the Bucholz site, west of Falls City. About a month later oil was found at a depth of 2,225 feet. On May 29, 1940 the bonus run began. The law read that the well must produce a minimum of 50 barrels of oil per day for 60 consecutive days. On July 27, 1940, the Bucholz Well became officially Nebraska's first producing oil well. During the bonus run it produced an average of 169 and one-half barrels per day. And Nebraska, after 75 years of trying, had at last discovered oil.

Now there's nothing like an oil strike to stimulate interest in finding more of the "black gold."

In 1940, 45 wells were drilled in Richardson and 12 more in the adjacent counties of Pawnee, Otoe and Nemaha. Twenty-nine of them were producers—all in Richardson County—located in the Falls City, Shubert and Dawson fields.

In 1941, 67 wells were drilled, 42 of them successful. One of them opened up a new field at Barada. This was the peak of the "oil play" in Richardson County. Exploration dropped rapidly and remained at a low level except for 1950 when there was a flare of activity. Seventy wells were drilled that year, 56 of them successful, prompted largely by efforts to extend known fields and recover oil at a deeper level.

The Richardson discovery created a splurge of drilling for oil in various parts of the state, other than the extreme southeast corner. In 1941 there were about a dozen. One of them, in Harlan County, was significant. Drillers found a substantial show of oil, but not enough for commercial production. The next year there were about a dozen more unsuccessful wells outside the southeast tip of the state. In 1943 there were about a score of wells drilled in various areas of the state.

NEBRASKA oil exploration dropped to a virtual standstill by 1948. There were some who expressed the fear that Nebraska Panhandle were being Richardson County and that its comparatively small area had been determined.

In this same year, however, substantial areas of land in the southwestern part of the Nebraska panhandle were being leased for oil rights. The Ohio Oil Company was making extensive tests to try to determine where oil might be found in the region.

Late the following spring the drilling rigs moved in and Ohio Oil Company spudded in a well near Gurley, about 12 miles north of Sidney in Cheyenne County. On June 9, 1949, a producing well was brought in. Oil in commercial quantities was found for the first time in western Nebraska. The Mary Egging No. 1 Well produced at a rate of about 400 barrels per day with a good quality oil. The oil bearing formation was in sandstones and shales buried 4,401 feet below the surface.

By the end of 1949, six producing wells were pumping oil from the Gurley Field, as it became known, with a potential of 1,000 barrels per day. A new and promising chapter in the history of Nebraska oil exploration had started.

The Panhandle's oil boom moved in high gear in 1950, and oil fever spread to many sections of Nebraska. Drilling rigs were operating in 29 counties, most of them in the western part of the state. Before the year had ended 214 oil and gas wells were drilled, 87 of them oil producers, 12 of them gas producers, and the remaining 95 were dry holes. The significant developments were these: discovery and development of the Dorman, Huntsman and McLernon Oil Fields in Cheyenne County; discovery of the Sunol, Huntsman and Southwest Sidney gas fields in Cheyenne County; discovery of the Big Springs Gas Field in Deuel County; and development of a commercially producing well in the South Alma Field in Harlan County, thus providing hope that an entirely new oil production basin, in central Nebraska, could be developed.

The last major exploration of the Richardson County oil fields also occurred in 1950. Seventy wells were drilled, 56 of them successfully. Mainly the drilling was aimed at (1) extension of the known fields, and (2) increasing production from a lower oil-bearing formation.

In 1951 there was no slackening in the search for oil in Nebraska, virtually the same number of wells being drilled as in the previous years. Nearly half of the exploration occurred in Cheyenne County. One signicant event occurred: oil in commercial quantites was discovered in Kimball, Banner and Deuel Counties. There was one chief discouragement: efforts to enlarge the oil discovery in Harlan County failed.

Exploration increased in 1952 to 313 tests in 38 counties, nearly a third of them successful. Oil was discovered in Morrill County, and another producer was found in Harlan County. In 1953, there were 333 oil and gas tests, about 35 per cent of them successful. The most significant event was, perhaps, extension of the Southwest Sidney Gas Field. In 1954, 516 oil and gas tests were drilled, nearly half of them successful. For the first time, the major exploration shifted from Cheyenne County to Kimball County where it has remained ever since. In 1955, exploration increased 70 per cent over the previous year. Drilling tests totaled 892, with slightly over a third of them successful. Eighty-five per cent of the "oil play" was in three counties—Kimball, Cheyenne and Banner. In 1956, 904 tests were drilled, with, again, nearly a third of them producers. And again, 86 per cent of the activity occurred in Cheyenne, Kimball and Banner Counties. There were two significant events beyond this three county area, however. Two producing oil wells were developed in Garden County, previously a dry-hole area, and a new oil field was developed in the central Nebraska area with a producing well developed in Red Willow County.

In 1957 there were 876 oil and gas tests drilled, 289 of them producers. Beyond the extension of oil production in Banner, Kimball, Cheyenne and Morrill Counties, the chief significant events were the discovery, for the first time, of oil in commercial quantity in Scotts Bluff, Red Willow, and Dundy Counties, thus extending the producing area of the western Nebraska producing basin.

IT is apparent, from this brief review of oil and gas exploration in Nebraska, that oil isn't always found where it's supposed to be. From 1939 to 1958 there were 4,475 oil and gas wells drilled in this state. About one of every three has been a producer. Now, before you are tempted to hire a drilling rig you should know that this success ratio includes wells that are drilled in known producing areas. Wildcatting, the search for oil or gas in areas beyond producing fields, is another matter. The crude oil and gas industry in Nebraska is like a man on a bicycle. As long as he keeps pedaling, the bicycle remains upright; as long as new fields are discovered, the industry continues to flourish. The odds against finding new commercial fields are greater. In Nebraska the ratio of wildcats to discoveries has been running about ten to one, which is about the national average.

These odds prevail even though geologists have accumulated much knowledge about Nebraska's sub-surface features, and special techniques have been developed to double-check this general knowledge. The best that can be said is that a particular area in Nebraska is *likely* to produce oil. You can never be certain in the search for new fields of oil or gas.

There are some basic conditions, however, which must be fulfilled before oil forms and collects. These were discussed earlier. How do they apply to Nebraska?

About 350,000,000 years ago, during the Paleozoic Era, Nebraska was part of a vast inland sea. During the latter part of this era, during what is called the Devonian system, the source materials for oil in southeastern Nebraska were laid down. At some later time the earth's crust was broken. Geologists describe this break as the "Humboldt Fault." It created a condition necessary for storage of commercial quantities of oil. This storage area is called the Forest City Basin, located in Richardson County. The basin extends into Iowa and Missouri.

In Nebraska's other major oil-producing area, the Panhandle, we find a somewhat different story. About 90,000,000 years ago Nebraska was again covered by another inland sea. This was, in case you are keeping track of the names, near the end of the Mesozoic Era, during what is called the Cretaceous System. Again the ooze of marine life and sediment created a condition necessary for oil to form. But there was no radical fracture of the earth's crust this time. Instead, the layers of rock and shale were uplifted at a gradual angle. In the process, oil-bearing formations were pinched off by impervious formations above and below them, forming stratigraphic traps. These traps are located in what is called the Denver-Julesberg Basin. The basin not only covers much of the Nebraska Panhandle, but the southeastern tip of Wyoming and much of the eastern third of Colorado.

WE have said that the basin slopes upward from west to east, whereas the surface slope is the opposite. What is the reason? This brings us to still an-

other prominent feature on the map of Nebraska's "basement" called the Chadron Arch, and its extension, the Cambridge Arch. The arch is exactly as the name implies. The basement rock of Nebraska was gradually uplifted during long periods of time into an arch, sloping to the west into the Denver-Julesberg Basin, and to the east into the Central Nebraska Basin.

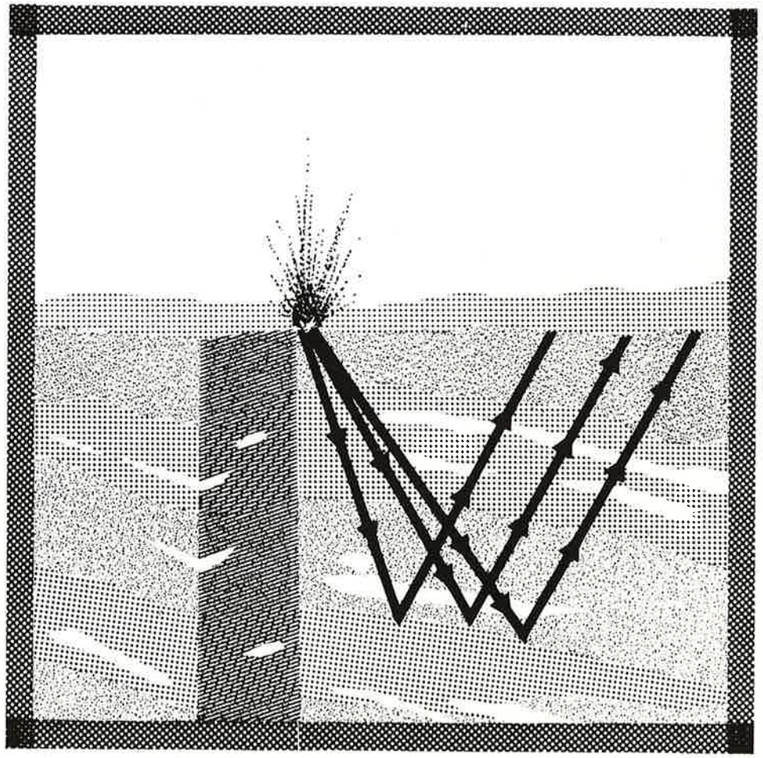
The Chadron Arch extends from the extreme northwestern corner of Dawes County in a southeasterly direction to the southeastern tip of Grant County. The Cambridge Arch picks up prominently at a point near Gothenburg in Dawson County, moves southeastward to the eastern edge of Frontier County, then swings south through the City of Cambridge and Red Willow County before leaving the state.

The importance of the Cambridge and Chadron Arches goes back to our original discussion of the rising and falling of the earth's crust. In this instance the arches have been responsible, in part, for the favorable structural formation of the Denver-Julesberg Basin in Nebraska. The arches, or the uplift which created them, also brought into being two basins on their eastern slopes. The first of these is the Central Nebraska Basin, a vast area covering all or parts of 63 counties and more than 39,000 square miles. Here are found, in varying degrees, the oil source rock, storage rock and the structural formations necessary for reservoirs. It now appears certain that this oil-producing source rock was laid down, as in the Forest City Basin, during the Paleozoic Era, and therefore, is a much "older" oil than found in the Panhandle. Some geologists believe that the Central Nebraska is an extension of the Salina Basin in Kansas. The second basin is centered in north-central Cherry County. This is known as the Kennedy Basin and is an extension of a similar formation in South Dakota.

We have said that underlying most of Nebraska—in four basins—are areas of potential oil production. Yet, within two of these basins, the Denver-Julesberg and the Forest City, a substantial number of unproductive wells have been drilled. Similarly a limited number of wells have been drilled in the Central Nebraska Basin, thus far largely unproductive except in Harlan County. We are now at the most perplexing stage of all in the search for oil. Exactly where, in these large basins, can we expect to strike oil in commercial quantities?

The most common method is, however, the seismograph. It works this way: The geologist sets off a charge of explosive in a relatively shallow hole. The sound waves travel downward. Some rocks reflect the waves poorly, others strongly. The reflected waves are recorded on a very delicate machine called a seismograph. After mapping a number of such explosions, geologists can usually locate a favorable oil bearing structure. But, here, as in the other methods, the results are not foolproof.

Certainly these methods, plus the general knowledge of the earth known to geologists, reduce the odds of a dry hole. But the hard fact still remains: Oil is found for sure only by drilling.



One of the most accurate ways of pin-pointing oil-bearing structures is by using a seismograph. A charge of dynamite is exploded. Waves of sound from the blast travel through the earth in all directions. Hard layers of rock send back "echoes" which are recorded on the seismograph. Engineers can interpret the tracings of these echoes to determine the depth and general nature of formations which may produce oil.

What Is Our Oil-Gas Future?

As Production Rises, Nebraskans Are Asking: How Long Will It Last? Conservation and Continued Exploration May Partially Determine The Answer

Nebraskans keep asking themselves questions like these about their state's oil and gas development.

Is this another flash-in-the-pan that will die out in a few years?

How much oil does Nebraska have?

Will there be another large discovery area like the southern Panhandle?

How does the present development compare with other oil-producing states?

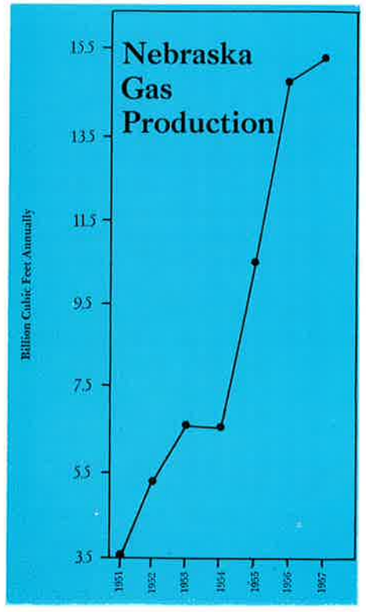
These questions and others reflect, perhaps, the native skepticism of a people (particularly in the eastern three-fourths of the state) who have alternately hoped for and dispaired of substantial petroleum wealth; or a cautious acceptance that just *maybe* Nebraska may become a prominent oil-producing state.

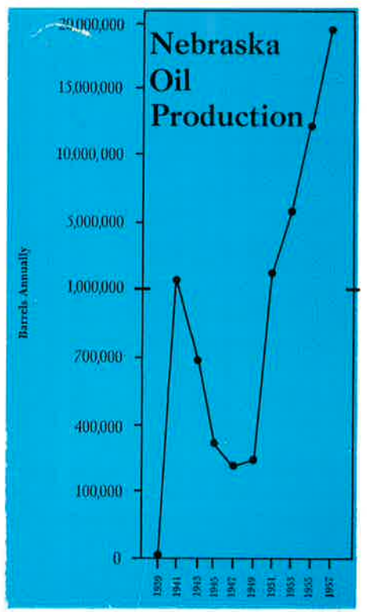
After all, it was barely 20 years ago that most Nebraskans were reasonably sure that searching for oil in Nebraska was about as rewarding as hunting for a needle in a haystack. Somehow Nature had perversely provided Kansas and Colorado and Wyoming with petroleum, but none for Nebraska, they believed.

Some were ready to admit they had been too pessimistic when, in 1939, a commercial oil field was discovered in Richardson County. Production that year was small (1,800 barrels) but at least it was oil, not rumor, and there was the promise of more. By 1941, production rose to 1,886,920 barrels. Nebraska took its place, about a third of the way up from the bottom of the list of oil-producing states.

Ten years after the first discovery well was brought in we weren't quite so sure about our bonanza. Production from the Richardson field was down to 197,146 barrels.

In that same year, 1949, commercial quantities of oil were discovered north of Sidney in Cheyenne County. Production by the end of the year totaled a modest 92,149 barrels. The next year new fields were developed





and production rose to 778,460 barrels. Since 1950, production has increased each year and in 1957 Cheyenne County fields yielded 4,841,135 barrels.

In 1951 wildcatting spread to many parts of the Denver-Julesberg Basin in the southern Panhandle of Nebraska. Commercial production was discovered in Banner and Kimball Counties. In the following year oil was discovered in Morrill County. In 1956 commercial production began in Garden and Red Willow Counties, and in 1957 in Scotts Bluff and Dundy Counties. All of these discoveries, except Red Willow and Dundy, are in the Denver-Julesberg Basin.

In 1950, the first commercial production, admittedly small, was discovered in Harlan County which is located in the Central Nebraska Basin. Meanwhile production has continued, although at a declining rate, in the Forest City Basin in Richardson County.

NEBRASKA was one of seven "oil states" which achieved new production records in crude in 1957. Among the statistical highlights are these.

(1) Total production was 19,615,880 barrels, an increase of nearly 20 per cent above 1956.

(2) Production in 1957 ranked Nebraska 13th among the 36 oil-producing states, compared with 14th in 1955, 17th in 1953 and 20th in 1951.

(3) All of Nebraska's production came from the Denver-Julesberg Basin except 155,828 barrels from the Forest City Basin and 6,641 barrels from the Central Nebraska Basin in Harlan County.

(4) Slightly over half of the state total production (10,655,991 barrels) came from Kimball County; and ten per cent of Nebraska production came from the 3,180-acre Sloss Field, located five miles southeast of the City of Kimball.

(5) Daily production per well in Nebraska averaged 44.9 barrels, compared with the U. S. average of 12.9 barrels, ranking Nebraska fifth in the nation in this respect.

(6) The state's 1,185 producing wells in 1957 produced a daily average of 53,164 barrels.

At the end of 1957 there were 115 producing oil companies operating in Nebraska. (Producing oil companies are those which pump and market crude from the field wells.) Ten of these companies were responsible for nearly 70 per cent of the total crude production. They are: Pan American Petroleum Co. 4,210,000 barrels; Ohio Oil Co. 2,618,000; Shell Oil Co. 1,642,000; British-American 974,000; Magnolia Oil Co. 742,000; Lowell J. Williamson 697,000; Petroleum Incorporated 625,000; Superior Oil Co. 605,000; Banner Oil Co. 496,000; and Chandler Simpson 461,000.

Six months after the Ohio Oil Co., in August, 1949, discovered oil in Cheyenne County, it discovered commercial quantities of natural gas in the Huntsman Field north of Sidney. A new phase of mineral production in western Nebraska began.

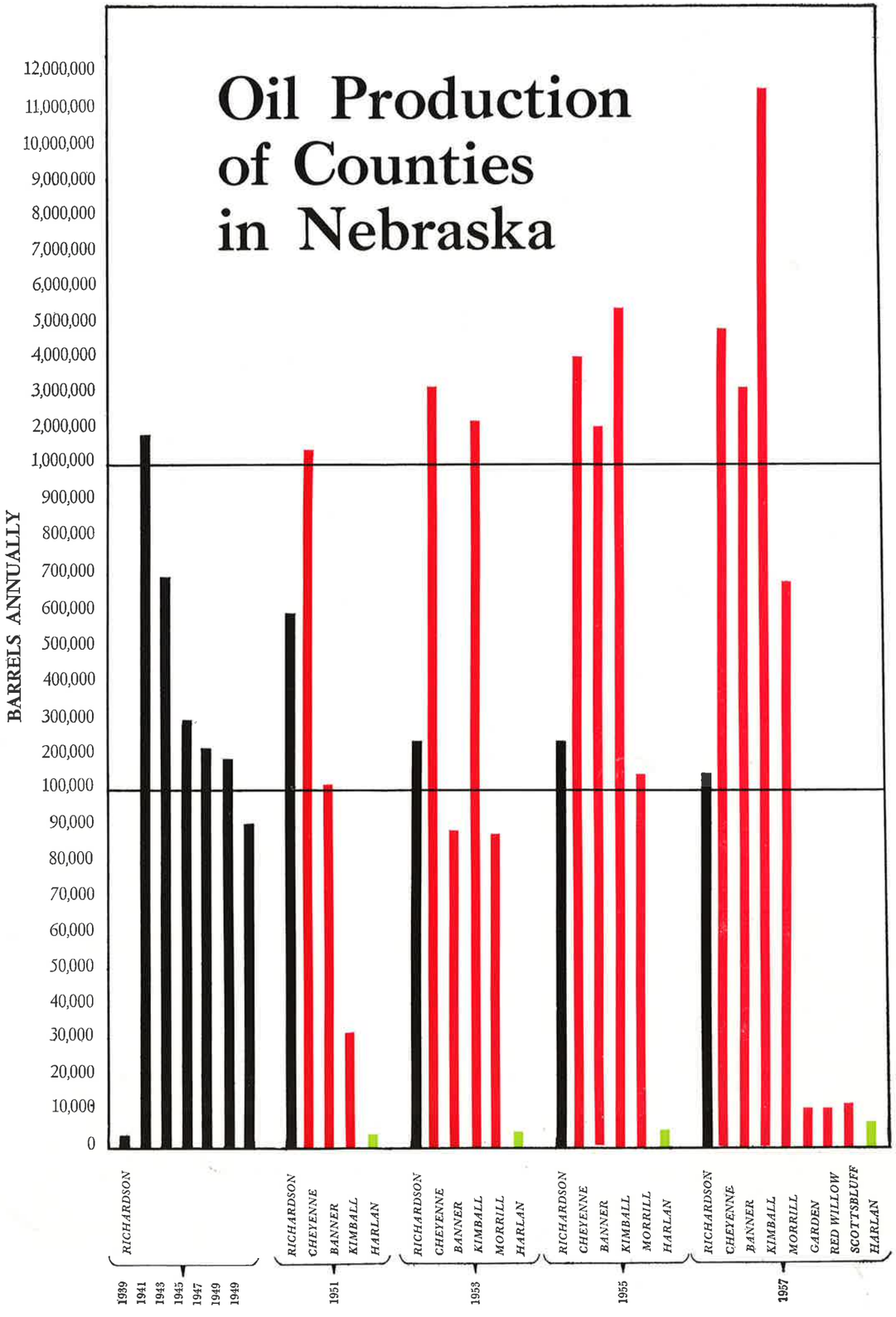
Later in 1950, following the Huntsman discovery, natural gas was discovered at the Sunol and Southwest Sidney fields in Cheyenne County, and in the Big Springs Field in Deuel County.

The discoveries were significant enough to warrant major pipe line transmission. Production was expanded in 1951 when gas in commercial quantities was discovered in Kimball County. In 1952 Banner County and in 1956 Morrill County, became gas producing areas.

In 1951 natural gas production totaled 3,678,666,000 cubic feet, or, as the industry usually measures production, 3,678,666 (MCF). Using the latter yardstick, natural gas production has increased steadily: 1952—5,309,013 (MCF); 1953 — 6,518,445 (MCF); 1954— 6,333,174 (MCF); 1955—10,478,368 (MCF); 1956—14,718,280 (MCF); and 1957—15,303,862 (MCF). About 57 per cent of the 1957 production came from the Cheyenne County fields.

BEFORE we take a look at Nebraska's growing natural gas industry let's take a brief look at the mineral itself. Wherever there is oil, there usually is natural gas in varying quantities; but where there is gas there need not necessarily be oil. Gas is held, under pressure, in the same porous rocks which form the basis of our subsurface oil reservoirs. When oil and gas are held together in the same reservoir rock, the oil will absorb all of the gas it can hold. If the reservoir holds more gas than the oil can absorb, the excess gas occupies the top of the reservoir area, forcing the oil into the sides or flanks of the reservoir structure. This is called a gas cap.

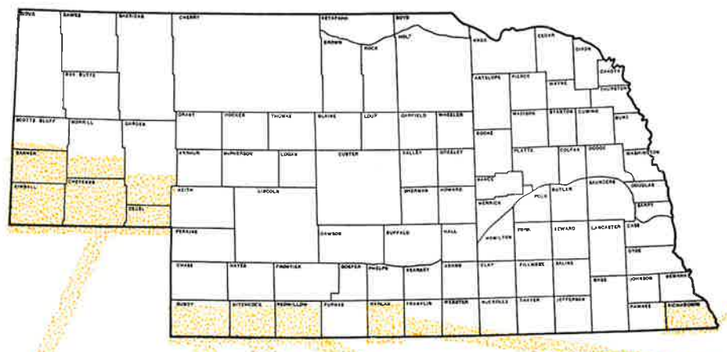
Gas, other than as a source of energy when extracted from the reservoirs, serves a very useful purpose. It is an expulsive force which (a) obliges oil to flow up the well casing several thousand feet from the bottom of the hold; or (b) forces oil from the reservoir rock to flow toward the well bottom from which point it is pumped to the surface. This second useful purpose occurs simply because the gas, under great pressure (between 1,000 and 1,600 pounds per square inch in western Nebraska, for example), moves in the direction of lessening pressure which is the well bottom. (Water also exerts pressure but this is another story discussed later.) If the well is pumped too rapidly, it is obvious that the gas will



escape at the same rate; and in the process of moving through the reservoir rock, leaving behind part of the oil in which it was dissolved. Most oil producers, of course, understand this and control production rates to permit extraction of most of the oil in the reservoir rock. This is one reason, incidentally, why the average oil well produces about 10 barrels of oil daily, whether it is flowing or pumped; whether it is capable of producing 50,000 barrels daily or much less.

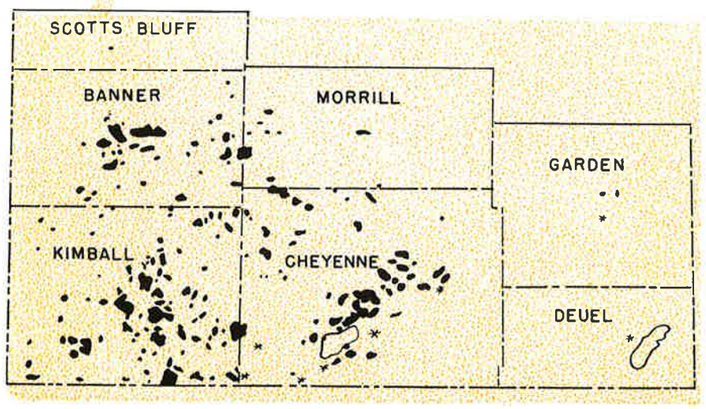
Now let's relate this information to the natural gas industry in western Nebraska.

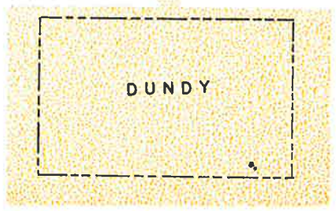
About 56 per cent of western Nebraska natural gas production comes from gas wells. The remaining 44 per cent comes from gas caps over oil reservoirs, and it is this source of supply which poses marketing problems. For example, the gas supply from these wells is determined by the oil production; that is, if there is a market for the oil the wells are turned on at maximum capacity and if not, they are shut in. This poses a problem of continuity and dependability for the gas producer. There is a second factor. Gas collected from oil wells usually has a high and varying content of liquid hydrocarbons absorbed from the oil. This causes the heat content (or BTU) to vary and to be higher than the BTU content of gas-well gas. There are also problems in transmission of oil-well gas. The marketer, therefore, must process this type of gas, and make other operating and marketing adjustments.



Over four-fifths of the natural gas production in Nebraska is marketed by the Kansas-Nebraska Natural Gas, Inc. of Hastings, Nebr. The remainder is marketed by the North Central Gas Company which absorbs the natural gas output of the Huntsman Field processed by the Ohio Oil Company's gasoline plant.

Suppliers for the Kansas-Nebraska include the Kimball Gas Products Co. which operates a gasoline plant servicing eight Nebraska gas-over-oil fields, and two Colorado fields; and the Ohio Oil Company's gasoline plant servicing principally the Southwest Sidney Gas Field which contains about 20 dry gas wells. One of the largest natural gas fields in the Denver-Julesberg Basin is the Big Springs Field in Deuel County. The field covers nearly 10,000 acres. There were at the end of 1957, 23 producing wells. The production of this field is taken by Kansas-Nebraska. The western Nebraska fields, and those in northeastern Colorado, supply about 30 per cent of the Kansas-Nebraska's pipe line requirements. The company estimates it has invested $5,640,000 in production, gathering and transmission facilities in western Nebraska and northeastern Colorado (as of 1957), and an additional expenditure of $3,267,000 for increased transmission facilities from Big Springs eastward to Grand Island.

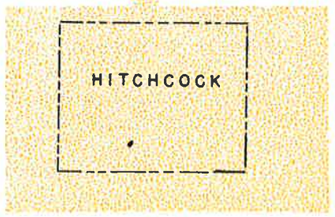




The oil and gas industry in Nebraska is as of the moment an important, but not a major part of the state's economy. In 1957, crude oil production, selling at an all-year statewide average price of $2.94 a barrel yielded gross sales of $57,148,108. Natural gas production for 1957, selling at an average price of 15.6 cents per thousand cubic feet, yielded revenue of $1,737,609 to producers and royalty owners.

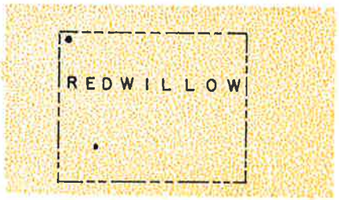
Some idea of the gross outlay made by the petroleum industry in western Nebraska in 1957 for exploration and development is given in the "Resume of Rocky Mountain Oil and Gas Operations in 1957" published by *Petroleum Information*. The report estimates these expenditures at $65,000,00 for last year.

In 1956, latest period for which figures are available, the federal government reported 1,210 persons, earning $5,790,000, were employed in the extraction of oil and gas in Nebraska. One hundred and twenty-two persons, earning $594,000, were employed in the processing of natural gas. Scores of Nebraskans, of course, have lease interests in both crude and gas production in the state from which they receive substantial sums; in fact, the Nebraska Oil and Gas Association, which represents the principal crude oil producers in the state, estimates that one-third of the expenditures of the industry in 1957 was represented in lease interest costs.



The oil and gas industry contribute, through taxes, to all levels of government. For example, mineral rights are considered real property but assessment is made upon a production basis in this state, rather than an estimation of total reserves lying beneath a particular parcel of land. In 1956 these mineral (oil and gas) rights were assessed at a basic value of $24,608,609. Tangible taxes are paid upon 50 per cent of this basic value.

In common with many other states, Nebraska has a severance tax on all natural gas and crude oil production, which in 1957 yielded $1,144,935. Royalties from state school land amounted to $6,612 from gas, and $350,211 from crude in 1957. This revenue is put in the state's permanent school fund. In addition, oil and gas lease rentals are charged producers operating on public school lands. Slightly more than 400,000 acres of school land are under lease for oil and gas, and rentals in 1957 totaled $330,107. This revenue is placed in the state's temporary school fund.



Within eight years, Nebraska became an important oil-producing state. The questions naturally arise as to how long it will last, and how much more oil discovery can be expected.

There are some qualified answers to these questions—qualified because a variety of factors are involved. But before we get into them, perhaps we should take a look at Nebraska's petroleum resources as part of the national situation.

Nebraska's 1957 production of crude oil, as encouraging as it is, represents less than one per cent of the two and one-half billion barrels produced last year in the U. S. Further Nebraska's proved crude oil reserves as of January 1, 1958 are estimated at 126,000,000 barrels, an increase of 33,000,000 barrels from January 1, 1957. Yet, as imposing as this figure may seem to Nebraskans, it represents 0.38 per cent of the known crude oil reserves in the U. S.

Similarly, on January 1, 1958, Nebraska's natural gas reserves were estimated at 247 billion cubic feet, up 22 billion cubic feet from January 1, 1957. Yet here again, Nebraska's share of the national natural gas reserve is less than a small fraction of one per cent.

Nebraska's Oil and Gas Fields

Shown on these two pages are the locations of Nebraska's producing oil and gas fields as reported by the end of 1957 to the University's Division of Conservation and Survey. The oil fields are shown in black. Gas fields are shown as black-outlined areas, and major gas wells are shown as stars.

About 56 per cent of this country's proved crude reserves (nearly 34 billion barrels) and 48 per cent of crude production (two and one-half billion barrels) are found in 204 giant fields located in the major oil states. These states are Texas, California, Louisiana, Oklahoma, Kansas, Illinois, Wyoming, New Mexico, Arkansas, Mississippi, Montana, New York, Pennsylvania, Colorado, Utah and North Dakota.

Now, if you add to the proved reserve figure for crude oil the unproved reserves, the industry comes up with the figure of about 90 billion barrels. You may ask: What in the world are we going to do with all this oil?

The answer is starkly simple. *The United States consumes a torrent of 350,000 barrels of petroleum every hour of the day and night.* This means, as any one can figure out, that Nebraska's total crude production in 1957 would supply this enormous demand for only 60 hours!

All other nations combined consume about as much oil annually as does this country. This, of course, underscores what we said earlier in this report that man truly is living in the Age of Petroleum. Many geologists, attempting to reconcile the available reserves against demand, believe the day of reckoning is near at hand. Others are confident that the bowels of the earth hold vast as yet undiscovered reserves which will postpone petroleum shortages for a long time to come. In either case the fact remains that man will ultimately exhaust this source of energy unless he can develop new ways to drive his machines.

THE important fact for Nebraska is (1) that the petroleum industry is driven to constantly search for new reserves; and further, (2) when oil or gas is discovered, to do all things necessary to insure their maximum withdrawal from the reservoir rocks holding them beneath the surface.

Perhaps we should consider the second factor first.

Let's take one final look at the reservoir rock in which we find oil far below the surface of Nebraska. Oil collects in commercial quantities in these rocks by moving from one point to another. The movement is accomplished by oil moving tortuously through spaces in the rock so small that a microscope is required to identify them. Force, therefore, is necessary to propel oil through these spaces. The force, or pressure, is exerted by water or gas or both.

When a drill strikes an oil reservoir, the sealed-in pressure area is punctured. The pressure is reduced at the point the drill enters the reservoir and the gas and oil move in the direction of lessened pressure. As oil flows, or is pumped, out of the hole, more oil rushes in to the bottom of the well. Now, if the oil is removed rapidly enough, the water or gas by-pass the oil, leaving much of it in the reservoir rock. Since water is present in all oil fields, in *some* it is also the chief pressure or expulsive force for the oil. In most fields, however, gas is the chief expulsive force.

To review: *Most* wells flow because of gas under pressure. Oil moves to the bottom of the well because of gas under pressure. To secure the greatest production from his wells, the producer must conserve gas. He does this by making every cubic foot of gas taken from the well bring with it the maximum amount of oil.

Everyone recognizes that all fields, sooner or later, are exhausted simply because each pool or field has a fixed amount of oil. When this is removed there simply isn't any more. The basic question is: Was every effort made to recover the maximum amount of oil in the field?

Let's illustrate this problem. Suppose you hold leases on half an oil field, and a stranger holds the leases on the other half. He pumps his oil out faster, and perhaps with more wells, than you do. The chances are your gas and oil will move in the direction of his wells, and pretty soon he is producing *your* gas and *your* oil. The oil is *his,* not yours! Why? Because the recognized "law of capture" says that the oil and gas belongs to the man who takes possession through wells, even if the oil and gas come from beneath land you own.

Oil field plunder was somewhat common in the early, hectic days of oil development in this country. Fields were discovered and exhausted rapidly, leaving much recoverable oil beneath the surface. The industry suffered alternate periods of feast and famine.

As time passed, it began to dawn on oilmen, and upon the public, too, that oil and gas were limited natural resources and that many production practices were wasteful and detrimental to producers and the public alike. Research and experience began to unveil the knowledge necessary to understand oil and gas accumulation, and the vital role of the underground energy of gas and water expelling oil from reservoir. With knowledge came understanding, and with understanding came acceptance (in and out of the courts) of the doctrine of correlative rights which has now been grafted rather firmly to the law of capture. This doctrine is the essence of oil conservation principles and transfers the focus from the oil well to the oil field. It says, in substance, that the industry and the public alike have a stake in an oil field; that extraction of oil is a concern with an entire reservoir in which all producers receive a fair or equitable share.

As a result of many years of legislative action by the various oil-producing states, of administrative decisions by state regulating agencies, of innumerable court decisions, and of a continuing self-disciplining by the oil industry including and notably the Interstate Oil Compact Commission, modern oil conservation practices have evolved.

Mr. J. C. Hunter, writing as President of the Mid-Continent Oil and Gas Association and Member of the Interstate Oil Compact Commission, sums up these practices in *Our Oil Resources* (McGraw-Hill, 1945) as follows:

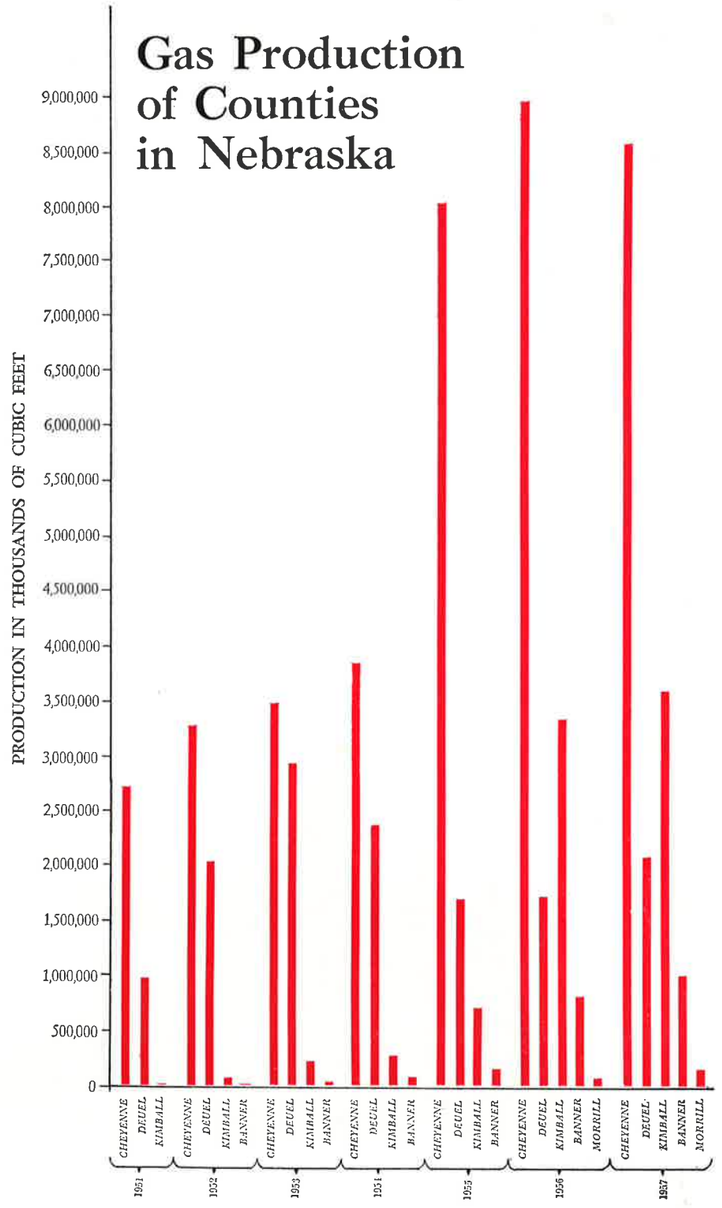
"Conservation of our oil resources is absolutely essential. Conservation is not hoarding; it is not holding back an exhaustible material for future generations. Rather, it is the prevention of the waste of an urgently needed natural resource. Waste prevention is in the public interest. It is necesary to ensure a continuous and economic supply of a vital ingredient of our national economy. In its broadest sense, waste prevention not only must include prevention of actual physical loss of petroleum, both underground and at the surface, but also must include deterrents to conditions that might lead to the diversion of petroleum to inferior uses.

"Fortunately, as a result of observing reservoir behavior and of the research and production practices employed during the period of effective conservation, a clear understanding has emerged of the physical principles and practices necessary to prevent the waste of petroleum. Stated briefly these principles are:

"1. One of the most important single factors affecting the ultimate recovery of oil from a reservoir is the rate of production.

"2. Uncontrolled, or wide-open production, causes underground waste.

"3. Restriction of the production rate is necessary to secure the maximum amount of recoverable oil. The degree of restriction will vary, but for any field a maximum-efficient rate of production exists that is subject to reasonably accurate determination and beyond which under-



ground waste will increase rapidly with further increase in the production rate.

"4. Production at rates in excess of market demand leads to waste both above and below ground and creates conditions leading to the diversion of petroleum to inferior uses.

"5. Control of the production rate entails the obligation of equitable allocation of the restricted production among the various operators in a field.

"6. The natural forces and energy residing in the water and gas associated with underground petroleum may be effectively employed at restricted rates of production to increase the ultimate recovery. Unnecessary waste of this natural energy must be avoided.

"7. An adequate number of wells properly located must be drilled in any field. The drilling of more wells than are actually required to produce the field at an efficient rate, without waste of gas and water and without excessive pressure decline near the well bore, constitutes excessive drilling. Excessive drilling is nonproductive use of capital and labor and leads to actual physical waste.

"8. Nonratable withdrawals cause waste. Nonuniform withdrawals may be prevented by control of the number and location of wells and by equitable distribution of production.

"9. In certain reservoirs deficient in natural energy the reservoir pressure can be maintained and waste prevented by supplying such energy in the form of injected water or gas. Such measures should be encouraged when their need is obvious.

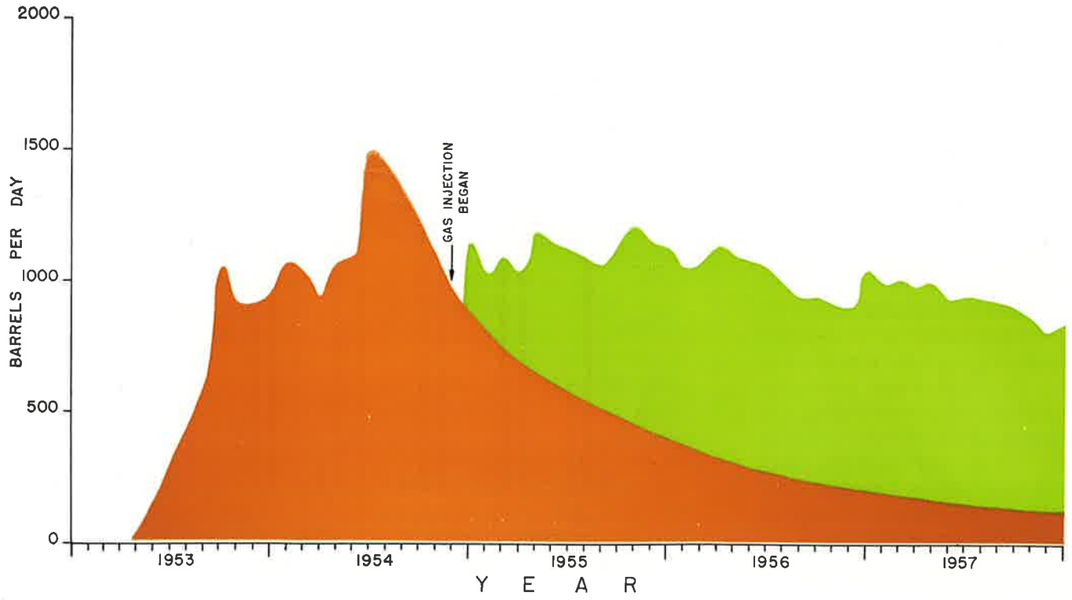
"10. An adequate underground reserve is required to permit the demand to be supplied at rates within the ability of the fields to produce efficiently. Conditions favorable to discovery of adequate reserves favor waste prevention.

"11. Proper determination of the natural reservoir conditions and of the efficient rate of production for each field is essential to any conservation program. Such determination must depend upon adequate geologic and engineering knowledge. Creation of conditions suitable for securing such knowledge therefore is an integral part of conservation. Frequently such knowledge is secured and exchanged on a cooperative basis."

Virtually all of the oil-producing states recognize these conservation principles in varying degrees, according to Mr. Hunter. And, since court decisions have consistently held that conservation of oil is a province of state authority in cooperation with the industry, the question of the wise use of this valuable mineral resource became a proper and continuing concern of state legislatures.

Now that the oil industry of Nebraska has passed beyond its initial stage of development, interest in adequate conservation control of petroleum in this state is developing. The impetus of the interest, it should be noted, derives from both industry and the public. Hearings have been held before a Committee on Oil and Gas Conservation of the Legislative Council, which is the interim study body composed of the membership of the 1957 Legislature. From this testimony it is anticipated that conservation legislation will be introduced at the 1959 session of the Legislature.

Secondary recovery is moving into Panhandle oil fields. At the Doran Field in Cheyenne County, natural gas was pumped into a field in 1954. The chart shows the production curve decline (brown area) if natural pressure had been utilized. The green area shows the production rise when gas was injected.



In a very real sense, conservation has already come to western Nebraska's panhandle fields in the form of a "secondary recovery" program. Secondary recovery is an effort to recover from an oil field petroleum which is still in the reservoir rocks after pumping under natural pressure becomes economically unfeasible.

There are two principal ways to secure secondary recovery. One is to pump natural gasses into a field; the other is to flood the subsurface oil reservoir with water. Without attempting here to describe how these two systems work in detail, suffice it to say that they create pressures which drive more oil from reservoir rocks to the wells. Either process is expensive but ordinarily oilmen expect to get at least twice or three times the amount of oil a field produced under natural flow or pumping.

Two Panhandle fields now have secondary recovery programs. One in the Doran Field west of Sidney in Cheyenne County where gas produced from the field is being pumped back into the reservoir by the Ohio Oil Co. The other is the Enders Field, south and east of Kimball, which is being water flooded in a program operated by the Shoreline Petroleum Co.

The necessity of the petroleum industry to keep available supply ahead of demand will dictate a continued extensive and expensive program of exploration or wildcatting. The extent of wildcatting may be temporarily influenced up or down from year to year by such factors as govenment policies and the state of the economy, but the long term outlook will be a continuous effort.

The petroleum industry in 1958, according to a survey made by the *Oil and Gas Journal,* expects to increase its wildcatting activities. In Nebraska it is expected that wildcat wells will exceed 1957's total of 492. No one knows where these wells will be drilled, but Nebraska offers a number of opportunities.

There are good possibilities that commercial oil and gas production may be extended beyond the present principal producing counties of Deuel, Cheyenne, Kimball, Banner, Morrill and Scotts Bluff.

Of special interest currently are eight counties in southwest Nebraska: Red Willow, Hitchcock, Dundy, Chase, Hayes, Frontier, Lincoln and Perkins. In Red Willow, for example, over thirty deep wells have been completed. Over 50 per cent of the dry holes have reported bona fide shows of oil from the Pennsylvanian. (All Nebraska production in the area thus far has been from a much younger formation, the Cretaceous.) Recent reports indicate that nearly all of Red Willow County is under lease, suggesting an expanded drilling program in the immediate years ahead. A noncommercial well was developed in east-central Hitchcock County in the fall of 1955 which produced three barrels per day for several weeks and then was abandoned. Bona fide oil shows have been reported in Pennsylvanian formations in Hayes, Frontier and Lincoln Counties. Several good oil and gas shows have been reported from both the Permian and the Cretaceous formations in Dundy, Chase and Perkins Counties.

Mr. R. F. Svoboda, Petroleum Geologist for the University of Nebraska Division of Conservation and Survey (now a private consulting geologist), in a report last year, drew these conclusions from southwest Nebraska's wildcat activity:

"Oil operators most likely to succeed in the location of new oil reserves in southwestern Nebraska will have drilled as a result of recommendations based on a thorough knowledge of the subsurface as revealed by all well records available plus a thorough study of geologic section during the drilling of an exploratory well.

"There is now a tendency among oil operators and geologists to quickly condemn a well or area based on what is incomplete logging or test data. The evaluation of an oil show based on study of drill cuttings alone is often very incomplete and highly inaccurate. Only on the basis of sample study, mechanical logging, drill stem testing, and coring can a possible oil reservoir on a wildcat location be actually condemned as non-oil bearing. . . . The so called 'dry hole' can only condemn the area immediately surrounding the test site which could more or less include a 10 acre site.

"If the exploratory drilling rate continues during the next few years in southwestern Nebraska as it has during 1955, 1956, and 1957, additional oil fields will almost certainly be discovered. Each well completed, even though dry, adds a little more knowledge of the subsurface for the petroleum geologists studying the area. Pooling of well data and information on a

voluntary basis by oil operators provides the means for experienced subsurface geologists to make sound recommendations that will undoubtedly result in locating new oil reserves for southwestern Nebraska."

The Division of Conservation and Survey, and industry geologists, have long held the belief that the geology in the Cretaceous formations of Box Butte, Dawes and Sioux Counties, and those parts of Sheridan and Grant Counties lying on the western flank of the Chadron Arch are favorable to commercial petroleum production. Evidence of driller's interest is found in the wildcat activity in this area. Since 1950, 52 wells have been drilled in Sioux County, 32 of them in 1957; 47 in Dawes, six of them in 1957; 35 in Box Butte, two of them in 1957; ten in Sheridan and six in Grant, none of them last year. All of the wells, thus far, have been dry holes.

The Central Nebraska Basin covers all or parts of 63 counties and includes an area of more than 39,000 square miles. Roughly its western boundary extends to Furnas, Gosper, Dawson, Custer, Loup and the southeastern one-third of Holt County before touching the northern border of the state. The eastern boundary is the Missouri River except in the southeastern corner where Pawnee, Richardson, the eastern half of Johnson, Nemaha, and the eastern halves of

continued on next page ⇢

Growing Pains at Kimball: An Oil Boom

University Report asked Arthur M. Henrickson, Editor and Publisher of the Western Nebraska Observer at Kimball to give it a first-hand account of the impact of oil on his home town. The following is his summation.

OIL has brought our town of Kimball more than money in the past seven years.

It has brought us people and pavement; new houses, new schools, trailers and churches. It has brought new businesses, new conversation, and has thrust us through a bewildering tax experience. And it's not over yet.

We began to talk about oil as a real possibility for the first time in 1949 when discovery was made in Cheyenne County to the east of us.

That was when the leasehounds got real busy and dickered with farmers right and left. Most people, though, talked as though it would be a joke. We had had some bumper wheat crops; prices were good, and farmers were well-to-do and not yet bothered with planting restrictions.

Right after the lease men came the seismograph crews. They exploded dynamite charges 200 to 300 feet below ground so the shock waves could be measured and the subterranean hills and valleys mapped. Funny thing. The discoveries, when they began, didn't follow the lines predicted by the studies; or rather, some did and some didn't.

The first commercial producer in our county was discovered in June of 1951. That was good news but it didn't cause any big boom. One tree doesn't make a forest, and one well doesn't make an oil field.

Of course, the number of drilling rigs increased. Fleets of tank trucks were hauling oil to pipe line terminals and the first service companies came in to finish the early wells. This was in 1951 and '52, you understand, when only a few discoveries had been made in Kimball County. We've got 760 producers now and oil men say there is three times more oil around here than has been tapped.

Kimball is twice as big now as it was in 1950 and with 2,050 population we are still growing. Our grade school enrollment increased from 450 in 1949 to 595 in 1952 and has since almost doubled again to 1,105. We've built two new grade schools and the second one is already being doubled in size.

Housing became a problem almost from the beginning. We had had no need for trailer parks and so trailers began blooming in vacant lots in every part of town. The city council passed an ordinance to regulate their placement. That was a lively subject for a while but trailers aren't emergency housing any more. They are spacious and spic and span with little picket fences, lawns and sidewalks.

Conventional housing developments appeared on what was farm land at the skirts of town; 60 to 100 new houses a year and still not enough. We had to have new streets, of course, and people wanted them wide with elbow room: 55 feet. The city agreed to pave the intersections and in no time at all we had a $200,000 paving bill. That, on top of other improvements—sewer lines, disposal plant, water mains, storm sewers, power lines and generating equipment—really put the pressure on our city budget. The levy shot from 50 mills in 1949 to a peak of 71 in 1956.

We got relief from our tax problem in an unexpected way.

As you might expect, people began drilling in town. The city was marked off into 40-acre blocks with the understanding that proceeds from any discovery was to be shared in equally by property owners in that block. The drilling was noisy but it brought in—so far—23 producers in the city and the pumps don't make more than a motor hum once they get going.

The tax relief came when the Supreme Court ruled that the city owns the oil under the streets and alleys. That has already returned more than $70,000 to the city and our tax rate dropped to 53 mills last year.

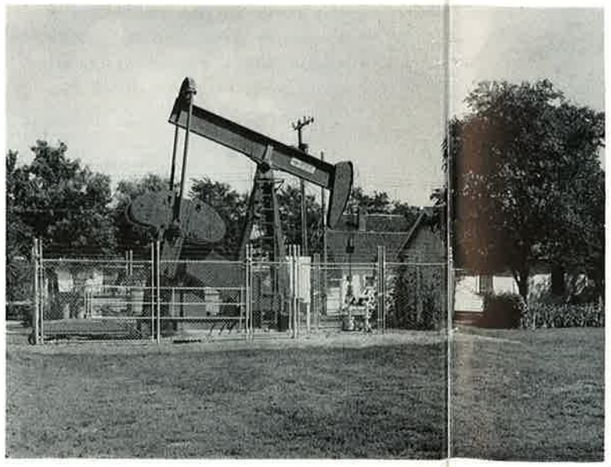
Our total oil production in Kimball County last year was valued at nearly $30 million and one-eighth of it went to the landowners in royalties.

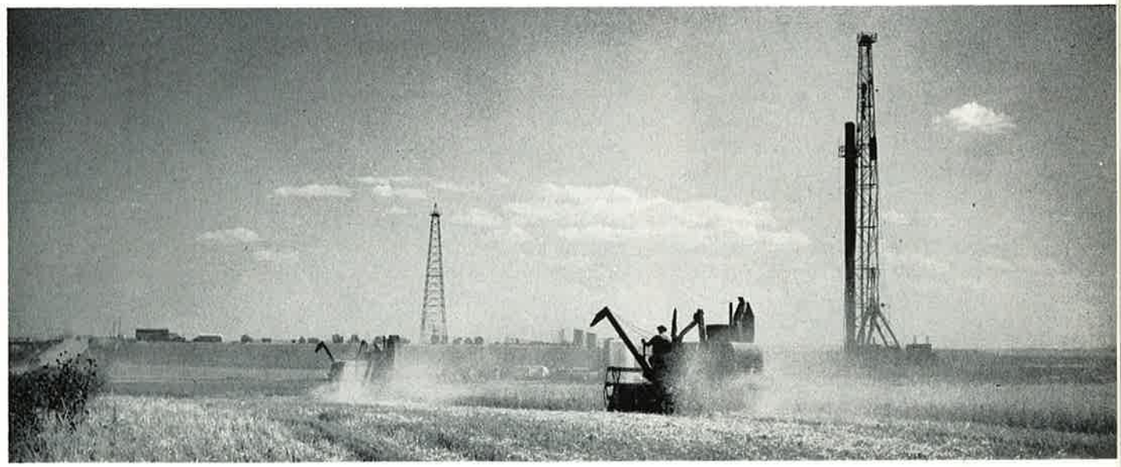
Naturally our business activity reflects what has happened. Where we used to have one store we now have two or more of the same kind and a lot of new kinds of businesses too, like the pipe and pump supply outfits. You can't miss their material yards at the edge of town any more than you could miss the farm machinery lots.

Speaking of farm machinery brings to mind what happened to our farming. We had some bad years. Hail cut down three-fourths of the 1953 wheat. Disease killed almost all of it in 1954, and in 1955 dust storms swept the fields bare. Kimball would have been as bleak as in the "Dirty '30's" if it had not been for the oil. As it was, a lot of farmers went to work with the oil crews.

Oil has certainly made the changes in Kimball and from the way things look it will make some more.

Changes a Quiet Western Farm Town





The photos at the right illustrate two aspects of the impact of oil on Kimball County. The City of Kimball now has 23 producers within its city limits, one of which is the pumper at the right. At the far right, wheat combines move between the oil wells. Farmers out there say they have the best rotation system in the world: Wheat and oil!

Otoe, Cass and Sarpy counties comprise the Nebraska part of the Forest City Basin. The Basin extends, of course, into Kansas on the south where it is known as the Salina Basin.

The Central Nebraska Basin has experienced only relatively scattered and sporadic wildcatting activity. About 190 wells have been drilled, nearly 100 of them to bedrock. Two producing fields, both in Harlan County, have been developed in this basin, but production has been limited.

Mr. E. C. Reed, Director of the Division of Conservation and Survey and State Geologist, expresses the belief that commercial production of oil in the Basin will most likely be found in the Pennsylvanian and Permian Age formations. Production in Harlan County is from Pennsylvanian Age formations, whereas principal production in the Denver-Julesberg Basin is from the Cretaceous Age Formations, and in the Forest City Basin from the Devonian Age formations.

"It is our considered opinion that there is good justification for more intensive exploration in the Central Nebraska Basin because of the intriguing possibilities that exist, and because all of the sedimentary (most likely oil bearing) section can be tested by drilling to depths of 5,000 feet or less," Mr. Reed says.

"Any detailed evaluation of the Basin should fully consider the time factor as it may affect the accumulation of oil or gas in commercial quantities. In other words, how does the probable time of petroleum generation and migration relate to the availability of a satisfactory trap and reservoir. The presence of low mineralization groundwaters in the pre-Pennsylvanian [formations] in many parts of this Basin is not regarded as a deterrent to effective accumulation. Obviously there has been extensive flushing of some reservoirs of high permeability, especially around the margins of the Basin but this fact does not preclude the possibility of effective structural closures where flushing has not occurred."

While the Forest City Basin is relatively small, it has been producing at a rate of 150,000 barrels or more annually since 1940. The Basin is a multiple-pay area, that is, commercial production is found in more than one formation. Some observers believe that further exploration of this Basin is desirable, and promising.

The Kennedy Basin is a relatively small basin in north central Cherry County. While there have been four or five wildcat wells drilled in this basin, not too much is known about its oil-bearing potential.

THE industry's point of view about Nebraska's oil and gas development is expressed best, perhaps, by a recent issue of the *Oil and Gas Journal.*

"After nearly eight years, Nebraska remains one of the busiest and most successful of the nation's oil provinces. Although there has been production in the state for many years, the real oil push didn't begin until 1949 at Ohio Oil Company's Gurley Field discovery well in the Denver basin of southwestern Nebraska. The state's first production was in the far southeast corner of the state in the Forest City Basin, but this area never blossomed into an important oil-producing province. The Denver Basin play, however, has fanned out in all directions. . . .

"For nearly two years the western and southwestern counties in Nebraska have led the Denver Basin exploratory and development program. Until the last few months northeastern Colorado's contribution to the Denver Basin race had dwindled considerably. Western Nebraska's part in the play remains strong.

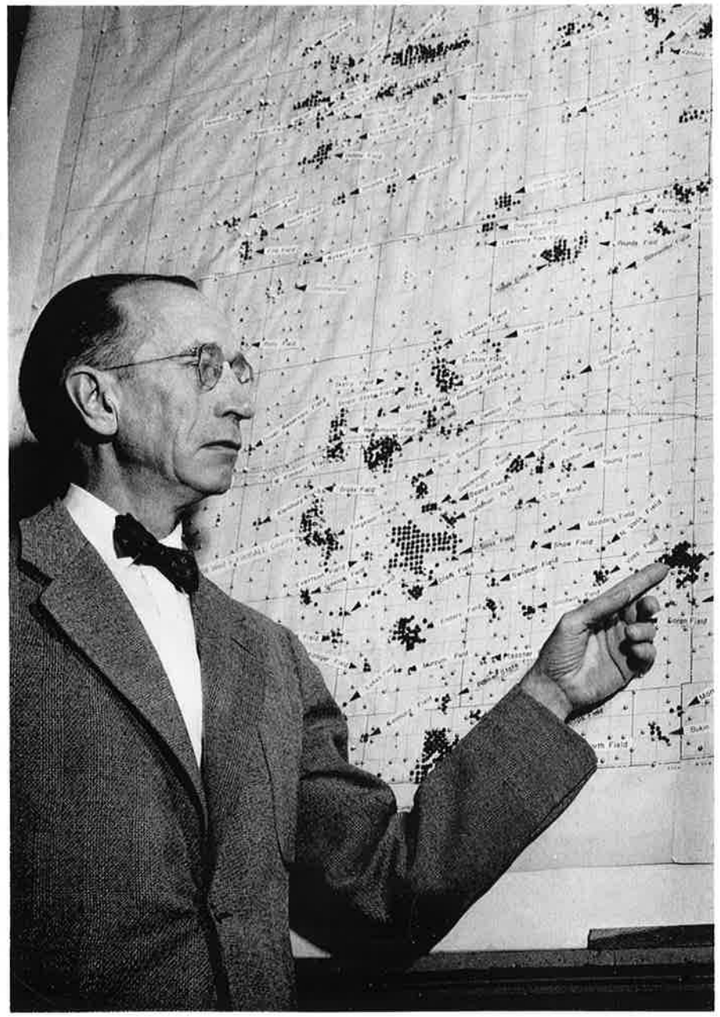
"The Sloss field in Kimball County, western Nebraska, is the state's biggest oil producer, and is the second largest in the entire Denver Basin. . . . The Sloss success illustrates the fact that the Denver Basin portion of Nebraska still holds many surprises and will continue to be one of the busiest of the Rocky Mountain provinces in the coming years. . . .

"Since the biggest percentage of Nebraska drilling has been in the far southwest and western counties, nearly three-fourths of the state remains sparsely tested. What the state needs is wildcats and lots of them. Success in any of the state's many regional uplifts and basins will set off a much-needed exploratory campaign in every corner of the state."

It seems reasonable to assume, at this juncture in Nebraska's oil and gas development, that there will be a continued and sustained exploration in the state for some years to come; that important new producing areas will be discovered in the not too distant future; that Nebraska, on the basis of present geologic information, will continue to be an important, if not a major oil and gas producing state in the U. S. Meanwhile, Nebraska may contemplate with some satisfaction that the petroleum industry has become a significant part of its economy.

The Role of The University

Basic Geological Research, Plus Varied Public Services and Training Programs Directly and Indirectly Assist Nebraska's Oil Development



THE development of Nebraska's oil resources provides us with an excellent example of the partnership of applied and basic research; and further, it illustrates the vital relationship of trained manpower to a highly technical enterprise.

Let's look at the research first. The basic scientist seeks knowledge for the sake of knowledge, to broaden man's understanding of his environment. The applied scientist, on the other hand, converts the basic information of basic research into tools with which he can solve practical, day-to-day problems.

For many years geologists of the University's Division of Conservation and Survey and of the Department of Geology have been investi-

The name of Mr. E. C. Reed (left), Director of the University of Nebraska's Division of Conservation and Survey and State Geologist, is associated in the minds of many Nebraskans with the conservation and wise use of the state's natural resources. He has, through his own research and the work of others under his direction, made valuable contribution to our knowledge of the geology of Nebraska. This has been especially valuable in the development of the oil and gas industry of the state.

gating the surface and subsurface geology of Nebraska. A substantial amount of information about the origin and evolution of the great land form of this state has been developed by men who, in large part, were motivated simply by an urge to know why Nebraska's surface and subsurface are as they are today. Indeed, Nebraska's knowledge of its geologic past ranks high in completeness among the states of the Union.

The oil driller is obviously interested in what lies beneath the state's rolling landscape. He wants to know, for example, if a formation of rock which produces oil in Wyoming also produces oil in Nebraska, or more likely, if the formation exists at all in Nebraska. He wants to know if oil-yielding rocks in Colorado or Kansas are found at the same depth, or deeper, or shallower in Nebraska. He wants to know if the Nebraska name for a certain group of sandstones is the same group which bears a different name in another state so that he may properly interpret his information.

Now, of course, an oil driller can move into Nebraska and search for oil on a hit and miss basis, and by successive failures and successes patch together some of the information he needs. Most drillers prefer, however, to have this basic information beforehand from a reliable source, which in this state has been gathered by the University of Nebraska. Armed with this, the driller can reduce tremendously the chances of failure.

HERE is a specific example of how basic research at your University, and the applied scientific skill of oil companies have served the state and the industry. Nearly two decades ago, Mr. E. C. Reed, then Associate Director, now Director of the Division of Conservation and Survey and State Geologist, undertook to relate rock formations underlying Nebraska with those in northwestern Colorado, eastern Wyoming, and the Black Hills Region of South Dakota.

In association with other geologists, Mr. Reed's primary mission was simply to advance the frontiers of geologic knowledge about this particular area. His painstaking study yielded these principal results: (1) determined the presence or absence of Colorado and Wyoming and South Dakota formations in Nebraska; (2) determined the depth and thickness of formations which existed in Nebraska and in the adjacent states or each of them; and (3) attempted to bring some orderliness to the correlation of names of these formations which in one state bear one set of names, in another state, still another set.

But beyond this excursion into basic geological research, his study established and correlated rock formations yielding gas and oil in Wyoming and northwestern Colorado with virtually the same formations underlying in Nebraska, particularly in the Panhandle. This was in 1940 when practically no one seriously considered looking for oil and gas under the Cheyenne, or Kimball or Banner county wheat fields.

In the summary of Mr. Reed's research bulletin is found this significant paragraph: "The Dakota Group of sandstones and equivalents which produce [oil and gas] in some fields in the Big Horn Basin, Powder River Basin, Laramie Basin, Sweetwater Basin all in Wyoming, and northeastern Colorado are known to be present in the subsurface of western Nebraska with possibilities of production under favorable conditions."

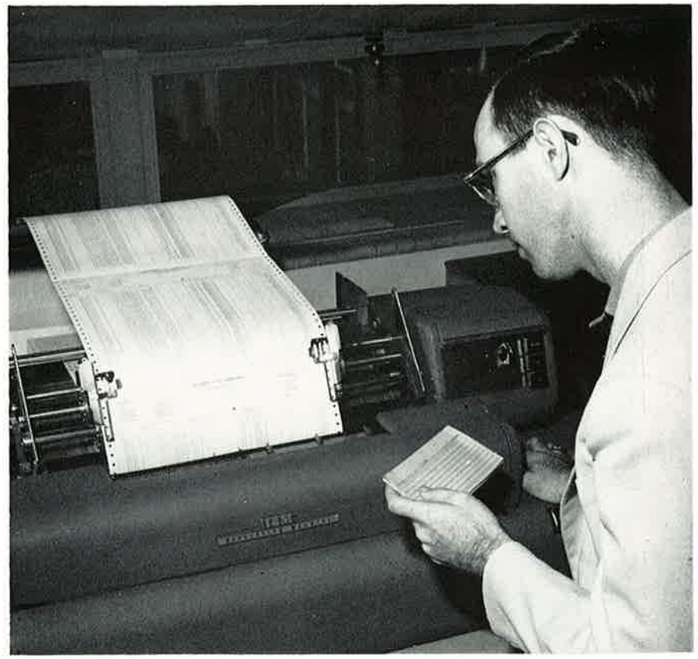
Eight years later, geologists and engineers of the Ohio Oil Co., assisted by the findings of basic research carried out by Mr. Reed and others, began an applied study of that part of the Denver-Julesberg Basin overlain by Cheyenne County. After extensive seismographing, the first producing oil well in the Panhandle region was discovered in June, 1949.

Since then, Mr. Reed's research, in association with other basic scientists, has pointed up the presence in Nebraska of several other subsurface rock formations, producing in adjacent states, which are producing oil in other parts of Nebraska. There are still others which have not yet been fully explored.

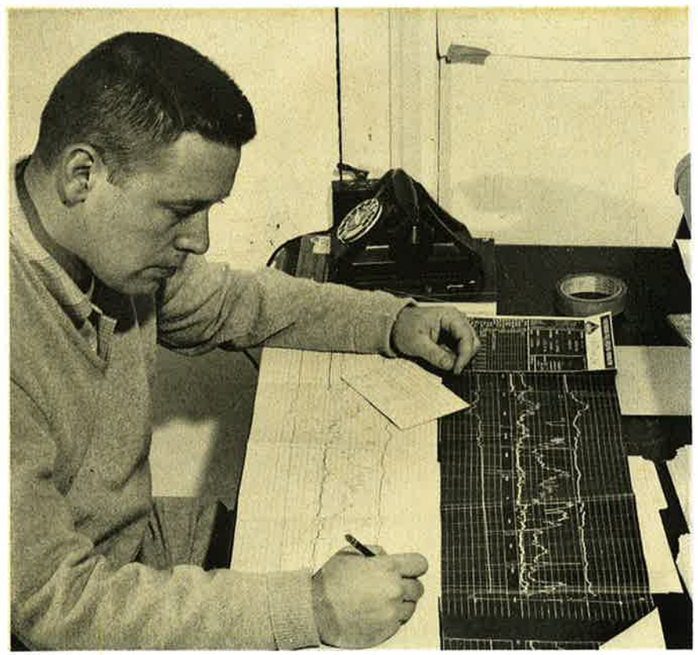
As Mr. Reed points out, geologic research is a two-way street. Every deep-well test completed in the state by the oil industry adds additional information to our knowledge of the formations underlying Nebraska.

THE Division of Conservation and Survey, which combines the functions of geologic research and the supervisory functions of the State Geologist's Office, also provides the oil industry, and interested Nebraska citizens, with a half-dozen public services which contribute to the development of oil and gas in the state.

(1) The Division is a source of reliable information. This, obviously, is very important because the records and samples of nearly all the deep wells are on file in its office. These can be consulted by interested persons who are capable of evaluating them and arriving at scientific justification for exploration of the state for petroleum.



Three aspects of the Division of Conservation and Survey's research and public services associated with the oil and natural gas development in Nebraska are shown in these photographs. Below is Mr. Earl Duncan, Curator of Samples, shown examining one of hundreds of samples of rock formations encountered in deep well drilling which are invaluable in assessing oil exploration possibilities. In the top photo at the right is James G. Johnston, Petroleum Geologist and Statistician of the Division. Record-keeping of the oil and gas development has become so voluminous that the data is now recorded and processed in the University's Machine Records Division. At the lower right photo is Norman L. Heinz, Sub-Surface Geologist, studying and interpreting electric logs of oil well drillings. These logs, when analyzed, yield valuable and precise information on subsurface geology in Nebraska, as well as providing interested firms or individuals with a graphic representation of drilling conditions in a given area, and depths necessary to test certain formations.



(2) It publishes reports and maps of geologic information from its Geological Survey. These are most valuable to oil companies or established independent drillers because they record basic data rather than pinpointing the possibilities of oil in a specific small area. (Occasionally promoters use these reports to lure small investors who are led to believe that the Division is endorsing the operator's particular well site.)

(3) The Division provides estimates of depths necessary to test certain geologic formations in any part of the state, and the probable drilling conditions which will be encountered. These reports are furnished upon request and provide an accurate basis for estimating drilling costs and bidding for drilling contracts. The reports are also valuable guides for the subsurface geologist who may be employed to log the well while it is being drilled, and which assist him in recommending depths at which special tests should be made. This information makes it less likely that prospective oil horizons will be drilled through without careful examination.

(4) The Division offers consultation services to oil companies and individuals interested in oil and gas development of the state. This service provides greater understanding of the general geologic conditions that obtain in different parts of the state and clarifies the judgments of those responsible for making decisions on exploration projects.

(5) Reports on geologic classification of materials drilled in wells is provided. The correct identification of geologic horizons drilled is invaluable in determining the distribution and nature of prospective oil or gas formations. In the infancy of the oil development of Richardson County the Division provided personnel to make on-the-spot identifications. This was of great assistance to small operators who did not have geological advice. This service has been abandoned because of the rapid growth of the oil industry in the state, and because of the shortage of trained personnel in the Division. However, the Division still provides this service if samples are brought in to its headquarters for examination while drilling is in progress.

(6) Landowners and other residents of the state can secure from the Division unprejudiced advice on general geologic information generally favorable to oil and gas development, as well as secure a reliable estimation of results after drilling operations have been completed.

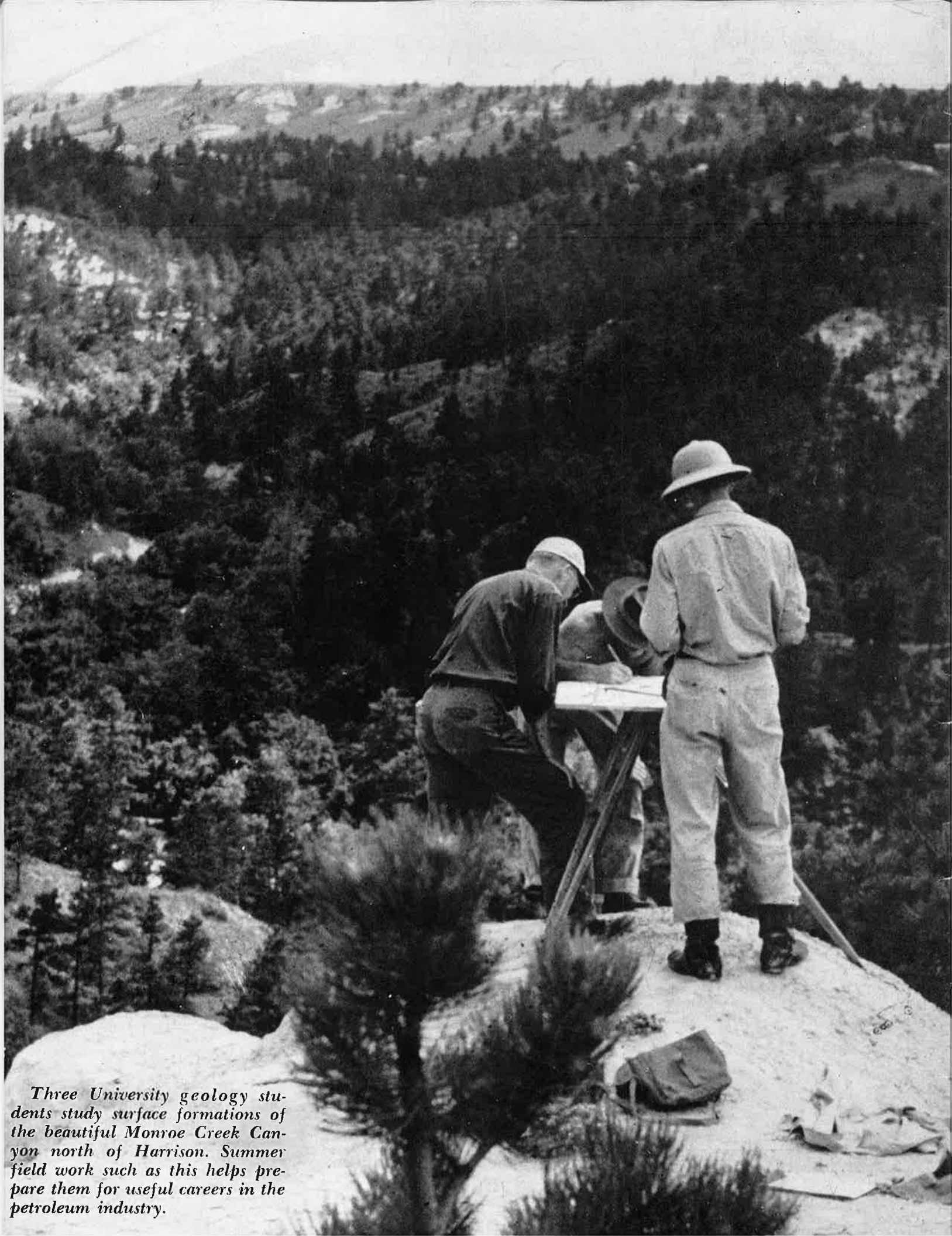
In addition to these services, the Division is charged with the enforcement of rules and regulations of the state geologist pertaining to gas and oil.

The University of Nebraska's Department of Geology has an excellent reputation in the nation's oil industry for the calibre of its graduates. Students are trained thoroughly in basic principles of geology, as opposed to highly specialized instruction in the various branches of this field. Shown here are four graduate students in a class in petrology. Shown, clockwise, starting at the left foreground are: Gene Irwin of Fairbury, George Karabatsos of Fairbury, Dr. A. L. Lugn, Professor of Geology, Harold NewVille of Lincoln and Jerry Docekal of Chicago.

THE University of Nebraska serves the oil industry of this country in still another way through its Department of Geology in the College of Arts and Sciences. Three of its current staff members, for example, have written nearly 60 scientific articles most of which deal with the geology of Nebraska. These men are Dr. A. L. Lugn, Dr. C. B. Schultz and Mr. Thompson Stout. In addition, many aspects of Nebraska geology have been illuminated by nearly 90 scientific articles written by advanced students seeking the Master of Science or Doctor of Philosophy degrees in geology.

For many years, under the leadership of Prof. E. F. Schramm, now retired, and presently under the Chairmanship of Dr. William Gilliland, the University's Department of Geology has trained scores of students for careers in geology. Many of the graduates of the Department now hold prominent positions in the oil industry, in geology teaching at other colleges and universities, and in various governmental agencies, state and national. For over 40 years Nebraska geology graduates have been very favorably considered by the oil industry, bearing out the soundness of the Department's teaching program. This program places its chief emphasis, according to Dr. Gilliland, in the fundamental subjects.

"We have avoided channeling our students into the narrow specializations which are involved in oil geology," Dr. Gilliland says. "Our curriculum stresses preparation in basic knowledge useful to all geology. The oil industry has often said that it seeks alert young men well-versed in sound, basic geology. As they mature in the industry their capabilities for specialization emerge more clearly."



Three University geology students study surface formations of the beautiful Monroe Creek Canyon north of Harrison. Summer field work such as this helps prepare them for useful careers in the petroleum industry.